This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

EducT
228.98
883

Laboratory Manual

OF

Inorganic Chemistry

Williams

Name .....

School .....

Room ..... Year .....

Educ T 228.95.883

HARVARD UNIVERSITY

LIBRARY OF THE

Department of Education

COLLECTION OF TEXT-BOOKS
Contributed by the Publishers

TRANSFERRED
TO
HARVARD COLLEGE
LIBRARY

3 2044 097 019 327

452

LABORATORY MANUAL

OF

INORGANIC CHEMISTRY

ONE HUNDRED TOPICS

IN

GENERAL, QUALITATIVE, AND QUANTITATIVE CHEMISTRY

BY

RUFUS P. WILLIAMS

IN CHARGE OF THE CHEMICAL DEPARTMENT OF THE ENGLISH HIGH SCHOOL, BOSTON AND AUTHOR OF "INTRODUCTION TO CHEMICAL SCIENCE," "CHEMICAL EXPERIMENTS, GENERAL AND ANALYTICAL"

BOSTON, U.S.A., AND LONDON
GINN & COMPANY, PUBLISHERS
The Athenæum Press
1898

Educ T 228.13.883

HARVARD COLLEGE
APR 1 1918
LIBRARY

Transferred from
Dep't. of Education Library

COPYRIGHT, 1896
BY RUFUS P. WILLIAMS

ALL RIGHTS RESERVED.

PREFACE.

For a decade teachers of elementary chemistry have given the author's Laboratory Manual a generous reception. To such he has felt under obligation to revise and bring it down to date. In the present Manual many of the former experiments have been omitted and new ones inserted, while all others have been completely rewritten. The greater number are devoted to general chemistry of the non-metals, as heretofore, while qualitative analysis of metals has received brief treatment, and that of acid radicals is somewhat expanded over previous editions. The very last experiments are of a quantitative nature, to give pupils a glimpse of more accurate volumetric and gravimetric work, and illustrate — as far as illustration is possible — the fundamental laws of chemistry. In the matter of directions for experimentation, in the setting up and handling of apparatus, a deal more of minutiae will be found than heretofore on those points in which a large experience has shown mistakes are most likely to be made. Illustrations are employed wherever the text seems to call for them — a change that doubtless will be welcomed alike by teacher and pupil.

The failure of pupils to obtain results in experimentation may be due to the omission of some minute detail which is of the most vital importance. Their failure to observe some of the important phenomena may be due to their not knowing what to look for. Effort has been made

to forestall the latter failure by constant suggestion and the fixing of attention by questions and notes on the important phenomena, without actually giving information.

Reasoning from phenomena to general principles and laws is introduced wherever possible, but only to a moderate extent. The beginner must not be expected to have the power of inductive reasoning which belongs to the professional. We are apt to expect too much and to forget that progress in a subject so entirely new must necessarily be slow, for the beginner has to learn: first, to manipulate apparatus; second, to observe phenomena; third, to ascertain causes; fourth, to correlate these and deduce laws; fifth, to record observations and conclusions; sixth, to learn two new languages, *viz.* the nomenclature and the notation of chemistry, and to learn them well enough to speak and write them — so much more is there in the teaching by the laboratory method of a science like chemistry than of a subject like history or English. But the results seem proportionally great, for so many more sides of the pupil's nature are touched in the one case than in the other. The great object in this teaching, in secondary schools, is to train the judgment. Teachers cannot too often impress upon pupils the necessity of using common sense in performing experiments and in reasoning upon the causes of phenomena.

CAMBRIDGE, MASS., Oct. 1, 1896.

SUGGESTIONS TO TEACHERS.

Much time will often be saved if a model of the app. to be used in making an exp. is set up for pupils to examine, and a few moments at the first of the hour are taken to explain the arrangement, manipulation, points of connection, etc., of the app. Samples of quantities of materials may also be put out if desired, as beginners are quite sure to get too large an amount. Pupils should be cautioned repeatedly against using too much time, in a lazy way, in preparing app. and in doing an exp.

If the laboratory period is quite short, it may be found desirable to use prepared app. as far as possible. Rubber stoppers instead of cork should almost always be used for this reason. Some teachers also prefer that pupils should write out their exps. — except the briefest jottings — outside of the laboratory. To the author this does not seem advisable, while he admits that much more can be accomplished in that way, and much neater and more complete books may result. But if this plan is followed, pupils are apt to rely too much on the text-book and too little on themselves. By writing results at once they get into more accurate and rapid habits of observation. If an exp. is done but not written out during the period, the student should complete it very soon thereafter, as he has time. It is not necessary to do all the exps. or to do them in the order given if you prefer some other order. In several cases (*e.g.*, Exp. 62) the teacher may prefer to do the exp. in presence of the class, who then take notes instead of doing it themselves.

It is suggested that the first few exps. be first written out on paper by the pupils, then discussed with the class, and finally rewritten in the books, with corrections and additions. All exps. ought to be discussed in presence of the class and by the members. The sooner this can be done after a laboratory exercise the better. At the discussion all points should be brought out, together with their bearing. A class thus becomes greatly interested. A laboratory period of two hours is most desirable, even if there can be but one a week, the last half

hour of it being used for discussion which if carefully carried on will greatly facilitate the accuracy of note-taking on the pupil's part and the examination of note-books on the teacher's.

Note-books ought to be inspected after each exp. or laboratory period if possible. Good English as well as good chemistry should be insisted on. The progress and relative rank of the experimenters may be ascertained by asking a few well-chosen questions of each as the teacher goes around to observe what is being done.

It seems desirable that the numbers of the exps. for the next laboratory period be announced or placed on the board, in order that pupils may prepare the subject before entering the laboratory.

It is at the discretion of teachers to ignore any or all the "Rules and Suggestions to Pupils," or to give additional ones.

Teachers should constantly bear in mind that the object is not wholly to teach chemistry, but to train the judgment of pupils, to make them careful observers and original thinkers.

RULES AND SUGGESTIONS TO PUPILS.

1. Each pupil should provide himself with a towel or cloth to keep his bench clean, and any apron or other clothing desired for protection in the laboratory. A long linen duster or duck coat reaching to the feet is the best protection. Without something of this sort clothing may be injured or ruined at any moment. Articles of gold or silver should not be worn in the laboratory, as the fumes are likely to tarnish them.

2. The bench at which you work must be left *clean* and *dry* after every laboratory exercise. Carefully wipe off a ring stand, lamp, or other apparatus on which a reagent has fallen, wipe out a p.t. after using it, and keep reagent bottles, apparatus, books, and lockers clean. Iron and steel objects must not be put away wet, or they will rust. Any substance dropped on the floor or side-table must be brushed or wiped up.

3. In experimenting, follow the directions as closely as possible, and ask an explanation of anything not understood. Have your apparatus neatly arranged, without artificial props, wedges, or uncouth-looking materials. All apparatus and chemicals must be clean and pure. Avoid putting a p.t. or other apparatus directly in front of the water faucet, or bowl, but place it at one side of the latter. To invert a rec. filled with water, see Exp. 13, Fig. 15.

4. Have every d.t. and stopper a close fit, to prevent leakage of gas. If a gas generates well but does not pass into the rec., there is some leakage, due probably to loose bearings. Old stoppers will scarcely ever do to use. Rubber stoppers may be used for a long time, but should be detached after every exercise. Before any tube is put into a stopper, make sure that it has been properly rounded (Exp. 5). To put a tube into a rubber stopper, moisten both the tube and the hole in the stopper. To put a stopper into a t.t., clasp the latter near its mouth with the left hand and gently press in the stopper with the right, keeping it perfectly straight, so as not to break the glass.

5. In heating a t.t. on a r.s. (Exp. 13, Fig. 14), hold the lamp in the hand, move it slowly, and now and then take it away from the tube

for a few seconds after the action has become vigorous, or the tube may melt and break. Never use a filter stand in place of an iron ring stand.

6. In heating a substance in an e.d. or a flask, have the latter usually not more than 5 or 10^{cm} above the top of the lamp, unless it is desired to heat slowly. If the ring which holds the plate cannot be easily lowered to that distance, put a small ring below on which to rest the lamp, but don't raise the lamp with books placed underneath. Have a ring above the flask to hold it in place (Exp. 38, Fig. 32).

7. Mixtures of solids should be made on paper, and thence carefully poured into the receptacle. You should have in your locker old newspapers, etc., neatly cut about the size of the leaves of this book. Use filter papers for nothing but filtering. *Small* splints should be used for testing combustion. *Be careful not to mix chemicals or reagents, whether solids or liquids, except as directed.* Sodium carbonate, Na_2CO_3 (dried), or bicarbonate of soda, $HNaCO_3$, bound on with a handkerchief, is a sure antidote for burns, if taken in time.

8. To mix the liquid contents of a t.t., cover its mouth with the thumb (Exp. 26, Fig. 26), the hand, or a stopper, *take it away from the bench*, invert it, and, if necessary, shake it vigorously. Pouring from one tube into another also mixes liquids.

9. Never put down a glass stopper, when using a reagent bottle, if you can avoid it, but hold it between the first and second fingers (Exp. 10, Fig. 11), and replace it when you put down the bottle. Do not pour back any excess of a reagent from a t.t. or rec. into a reagent bottle, and do not dip a s.r. or a pipette into a reagent bottle. In reddening litmus paper for use, never dip it into an acid, but hold it in the *fumes* of HCl. To turn it blue, use the fumes of NH_3.

10. In pouring a liquid into a t.t. or graduate, hold the latter on a level with the eye, towards the light, and in such a way as not to conceal the substance already therein, but so as to see any phenomena. The thumb-nail may be placed at the desired upper limit of the liquid. If much heat is liberated (as when sulfuric acid is poured into water) a tube-holder should be used; paper folded several times serves well.

11. Pour only liquids, fine solids, or soluble salts into the sinks, *always opening the faucet first to let the water run.* Other solids should be thrown into the jars. *Great care must be taken not to clog the discharge pipes with glass, matches, or other solids.*

12. Wipe your flask, e.d., or tube perfectly dry on the outside before applying heat. Tubes of thick glass, if they contain no liquid, should be heated gradually by moving them rapidly into and out of the flame. When once heated they may be held steadily in the flame. If a hot flask or tube holds a liquid, it is not injured by pouring water on the outside, but if it contains only a solid, or is empty, it should be cooled till it can be handled, or water will break it.

13. Before lighting the gas of a Bunsen burner, open the jet to its full capacity. If the gas "burns at the base" (shown by its peculiar flame), extinguish and relight it. Turning it half on before lighting is likely to cause the flame to set back. The hottest part of a Bunsen flame is about half way up, just above the inner cone. Substances to be strongly heated should be held there.

14. On entering the laboratory, take your note-book, open the locker, take out your towel and such apparatus as you need for the exps., placing them on the bench in front of you. Prepare for doing the first exp. of the day, and read it entirely through before attempting to perform any part of it.

15. *On leaving the laboratory be sure that everything is put back in place, the part of the bench you have occupied wiped clean and dry, and the locker locked.* Reagents for general use must not be taken to the individual's bench, but left at the side-table, and *nothing must be put into your locker except what belongs there.*

16. Before every laboratory exercise you should make as thorough preparation for the experiments, by studying a text-book, as you would for a recitation.

17. Endeavor to carry away from each exp. a mental picture of the apparatus as it is set up, of the colors and appearance of the substances used, and of the products obtained, — whether they are solids, liquids, or gases, in solution or not, crystalline or amorphous, etc. In recalling and describing exps. state all of these, together with the names and symbols of the factors and products, but do not try to recall quantities of substances used. By noting and comparing the colors and odors of gases many substances can be recognized. To take the odor of a noxious gas, waft some of the gas with the hand from the mouth of the tube or rec. to the nose, thus diluting it.

18. Cover this book with heavy paper, and write your name and room in printed capital letters distinctly across the front edge of the book, having the latter closed. No notes should be made in the book

outside of the laboratory without special permission. The book should be left in the laboratory at the end of the hour, and no other book should be used in connection with the exps.

19. It is of the greatest importance that you should see all there is in an exp., and the order in which changes take place, and state your observations briefly and in correct English. Your notes should embody the following points, and be written on the page opposite the directions: (1) *Chemicals* (names and symbols), *apparatus* and *adjustment* (very briefly and not copied from the directions). (2) *Observations* and *results* (such as whether solid, liquid, or gaseous, the color, odor, increase of temperature or of volume, effervescent action, precipitation, sublimation, etc.). (3) *Explanation* of each change (*i.e.*, what it indicates to you, or how chemists account for the phenomena), together with an equation where this is possible. *Put the main stress on* (2) *and* (3). Questions, calls for observations, etc., in the directions are suggestive only, and not intended to indicate the complete notes. Study carefully the *Models* for taking notes, and follow them closely unless your teacher gives other directions. Try to distinguish in an exp. what you see that is important from what is not so, and whenever you give an explanation think *whether the exp. teaches it, or whether you have got it from some outside source.* Put each equation on a line by itself immediately following the explanation it is intended to complete. Indicate gases in an equation by a brace above the symbol, as $\overbrace{NH_3}$, and ppts. by one underneath, as $\underbrace{PbSO_4}$. Record of an exp. must be made on the spot, either as soon as the exp. is completed, or often before it is done, at a convenient place for a pause. For valences, symbols, names, solubilities, etc., of substances, refer to the front pages of the book; if they are not there, consult the teacher. Be sure to read rules and cross references mentioned in an exp.

20. Finally, endeavor to use the best of judgment and common sense in making the experiments, and also in drawing conclusions and taking notes. Pupils who experiment are divided into two classes. One follows blindly the directions without thinking what the exp. is for, or what are the results obtained. The other studies why a thing is to be done, observes with the utmost care the result of every step, and constantly asks: "What does this teach?"—at the same time not dawdling, but working expeditiously.

SUGGESTIVE MODELS

For Writing out Experiment Notes.

Exp. 9. I put into a test tube 5^g — as near as I could estimate — of sugar, $C_{12}H_{22}O_{11}$, which is a white, crystalline, sweet solid, and poured over it 5^{cc} of water, H_2O. No change apparently took place. Holding the tube in the Bunsen flame I noticed the liquid soon began to boil, or effervesce, and the sugar to disappear. From this I supposed it was dissolving in the water. Soon the sugar had entirely dissolved, and the solution was clear and colorless.

I then cooled it, as directed, and tasted a drop from the stirring rod. The taste was sweet, which showed that the sugar was still present, though too finely divided to be seen. As a drop from any part of the liquid is equally sweet, I infer that the small particles of sugar are well distributed among the particles of water. Since the sugar does not seem to be changed into anything else, I conclude that the solution of sugar in water is merely a physical change, not a chemical.

On diluting the solution with an equal volume of water it is still sweet, though less so than before, from which I suppose the sugar particles are still more finely divided, or further apart than at first.

I filtered the solution, as directed, and found the filtrate still tasted sweet and there was no residue on the filter paper. From this it appears that sugar in solution is so finely divided that it will go through a filter paper.

Exp. 10. To the remainder of the sugar sol. from Exp. 9 I slowly added sulfuric acid, H_2SO_4. I first noticed that the colorless sugar sol. began to turn brownish-red at the bottom, then the color became darker, and finally black, and this change rapidly extended upward through the whole mass. Minute bubbles rose at the same time, showing an effervescing action and the escape of a gas or vapor.

The tube also became very hot, from which I thought the effervescence might be due to the boiling of the water. I noticed a strong odor of burnt sugar. The contents of the tube began to swell, and

finally ran over the sides of the tube — a black mass with apparently very little liquid, and with none of the appearance of the original sugar or water. It looked much like finely divided charcoal.

The heat, the odor, and the change of color, state, volume, and properties of the substance, all indicated that a chemical change had taken place.

The explanation of the exp. is that sulfuric acid has great affinity for water, and combines first with the solvent water, and then — if the sol. is strong — it breaks up the sugar $C_{12}(H_2O)_{11}$ to get more H_2O. This leaves the finely divided carbon, which in turn absorbs the diluted acid into its pores.

INDIVIDUAL APPARATUS.

Each pupil should be provided with the apparatus given below, but in cases where great economy must be exercised different pupils may, by working at different times, use the same set. The author has selected apparatus specially adapted, as to exact dimensions, quality, and cheapness, for performing in the best way the experiments herein described, and sets or separate pieces of this, together with other apparatus and chemicals, can be had of the Ziegler Electric Co., 141 Franklin Street, Boston, to which firm teachers are referred for catalogs.

4 reagent bottles, 250cc, glass stoppers, blown labels: NH_4OH, HCl, HNO_3, H_2SO_4.
1 pneumatic trough.
1 Hessian crucible.
2 beakers.
2 pieces wire gauze.
1 piece platinum wire.
1 mouth blowpipe.
6 pieces glass tubing.
4 pieces hard glass tubing.
1 test-tube brush.
1 small tube brush.
1 dozen test tubes, with cork stoppers.
1 fish-tail attachment for Bunsen burner.
1 blowpipe attachment with rest for Bunsen burner.
1 piece sheet copper, 2″ sq.
1 glass retort.
1 tumbler.
1 piece cobalt glass.
1 horn spatula.
1 camel's-hair brush.
4 wide-mouthed bottles.
1 2-holed and 1 3-holed rubber stopper to fit above.
4 pieces window-glass.
1 glass funnel.
1 porcelain evap. dish.
1 asbestos board.
1 pair iron forceps.
1 triangular file.
1 round file.
1 piece copper wire.
1 piece lead wire.
1 piece zinc wire.
1 test-tube holder.
1 wire test-tube rack.
1 thistle tube.
1 Bohemian flask.
1 2-holed rubber stopper to fit flask.
1 Bunsen burner.
1 iron ring stand.
2 ft. rubber tubing.
1 ft. " "
1 metric ruler.
1 graduate.
1 small leaden dish.

GENERAL APPARATUS.

The requirements of general apparatus for a laboratory are too numerous and varied to be given here. A few of the pieces in more general demand for experiments in this book are as follows:

- Glass-stoppered bottles.
- Graduates.
- Funnels.
- Fruit jars (for making solutions).
- Scales, with metric weights.
- Ignition tubes.
- Beakers.
- Filter stands.
- Glass and rubber tubing.
- Steel glass-cutters.
- Steel wire-cutters.
- Mortars and pestles.
- Flasks.
- Filter papers, etc.

CHEMICALS.

ESTIMATE FOR A CLASS OF TWENTY.

Acid, acetic, $HC_2H_3O_2$	1 lb.
" hydrochloric, HCl	15 "
" hydrofluoric, HF	2 oz.
" nitric, HNO_3	10 lb.
" sulfuric, H_2SO_4	12 "
Alcohol, C_2H_5OH	1 pint.
Aluminum chlorid, $AlCl_3$	½ lb.
Ammonium carbonate, $(NH_4)_2CO_3$	1 "
" chlorid, NH_4Cl	1 "
" hydrate, NH_4OH	4 "
" nitrate, NH_4NO_3	2 "
" oxalate, $(NH_4)_2C_2O_4$	½ "
" sulfate, $(NH_4)_2SO_4$	½ "
Antimony (metal pieces), Sb	½ lb.
" chlorid, $SbCl_3$	½ "
Arsenious oxid, As_4O_6	1 oz.
Barium chlorid, $BaCl_2$	½ lb.
" hydrate, $Ba(OH)_2$	½ "
" sulfate, $BaSO_4$	½ "
Bismuth oxychlorid, BiOCl	3 oz.
Boneblack, C	1 lb.
Cadmium chlorid, $CdCl_2$	2 oz.
Calcium chlorid (granulated for drying tubes), $CaCl_2$	2 lb.
Calico	——
Candles	——
Carbon disulfid, CS_2	½ lb.
Charcoal (powdered), C	2 "
Cobalt chlorid, $CoCl_2$	1 oz.
Chromium chlorid, $CrCl_3$	1 "
Cochineal	½ lb.
Copper turnings, Cu	2 "

Copper wire ($\frac{1}{16}$ in. diam.) 14 ft.
" chlorid, $CuCl_2$ ½ lb.
" nitrate, $Cu(NO_3)_2$ ½ "
" oxid, CuO ½ "
Disodium phosphate, HNa_2PO_4 ½ "
Ferric chlorid, $FeCl_3$ ½ "
Ferrous sulfate, $FeSO_4$ ½ "
Ferrous sulfid, FeS 3 "
Filter papers (6 in.) 1000.
Potassium bisulfate, $HKSO_4$ 2 oz.
Gold leaf 1 book.
Indigo 1 oz.
Iodin, I 1 "
Lead, Pb ½ lb.
" wire ($\frac{1}{16}$ in. diam.) 14 ft.
" acetate, $Pb(C_2H_3O_2)_2$ ½ lb.
" chlorid, $PbCl_2$ ½ "
" nitrate, $Pb(NO_3)_2$ ½ "
" oxid, PbO ½ "
Litmus cubes 1 oz.
" paper ¼ quire.
Magnesium chlorid, $MgCl_2$ ½ lb.
" sulfate, $MgSO_4$ ½ "
Manganese dioxid, MnO_2 3 "
" chlorid, $MnCl_2$ ½ "
Marble chips, $CaCO_3$ 3 lb.
Mercuric chlorid, $HgCl_2$ ½ "
Mercurous nitrate, $HgNO_3$ ½ "
Naphtha 1 pint.
Nessler's solution ½ lb.
Nickel chlorid, $NiCl_2$ ½ "
Paraffin ½ "
Picture wire (large) 10 ft.
Platinum foil, Pt 100^{qcm}.
" chlorid sol., $PtCl_4$ 1 oz.
Potassium, K ½ oz.
" bichromate, $K_2Cr_2O_7$ ½ lb.
Potassium bromid, KBr ½ lb.
" carbonate, K_2CO_3 ½ "
" chlorate, $KClO_3$ 2 "
" chlorid, KCl ½ "
" chromate, K_2CrO_4 ½ "
" cyanid, KCy 1 oz.
" ferricyanid, ½ lb.
" ferrocyanid ½ "
" hydrate, KOH ½ "
" iodid, KI ½ "
" nitrate, KNO_3 ½ "
" nitrite, KNO_2 ½ "
" sulfocyanid 1 oz.
Quicklime, CaO 1 lb.
Silver nitrate, $AgNO_3$ 2 oz.
Sodium, Na ½ "
" acetate, $NaC_2H_3O_2$ ½ lb.
Sodium arsenite, Na_3AsO_3 ½ "
" bicarbonate, $HNaCO_3$ ½ "
" carbonate, Na_2CO_3 1 "
" chloride (coarse), NaCl 3 "
" chloride C.P. ½ "
" hydrate, NaOH 1 "
" hypochlorite, NaClO ½ "
" nitrate, $NaNO_3$ 2 "
" sulfate, Na_2SO_4 ½ "
" sulfid, Na_2S ½ "
" borate $Na_2B_4O_7$ ½ "
" silicate, Na_4SiO_4 ½ "
Splints 10 bunches.
Starch, $C_6H_{10}O_5$ ½ lb.
Strontium chlorid, $SrCl_2$ ½ "
Sugar, $C_{12}H_{22}O_{11}$ 2 "

Sulfur, brimstone, S	1 lb.	Zinc, granulated, Zn	4 lb.
" flowers, S	½ "	" (arsenic-free)	2 "
Tin chlorid, $SnCl_2$	¼ "	" wire ($\frac{1}{16}$ in. diam.)	14 ft.
Turkey red cloth	——	" chlorid, $ZnCl_2$	¼ lb.
Turpentine (spirits of,) $C_{10}H_{16}$	3 oz.	" nitrate, $Zn(NO_3)_2$	¼ "

Chemicals used in analysis should be C.P. (chemically pure). For use in *general chemistry* such substances as HCl, H_2SO_4, etc., may be the commercial variety, but in analysis even these must be C.P.

ABBREVIATIONS.

---

app. — apparatus.
cc — cubic centimeters.
cm — centimeters.
cpd. — compound.
dil. — dilute.
dis. — dissolve.
d.t. — delivery tube.
e.d. — evaporating dish.
Exp. — experiment.
g — grams.
gen. — generator.
insol. — insoluble.
i.t. — ignition tube.
N.T.P. — normal temperature and pressure (0°, 760mm).
ppt. — precipitate.
p.t. — pneumatic trough.
qcm — square centimeters.
reagt. — reagent.
rec. — receiver (wide-mouth bottle).
r.s. — ring stand.
sat. — saturate.
sol. — solution.
sp. gr. — specific gravity.
s.r. — stirring rod.
t.t. — test tube.
vol. — volume.

TABLE OF COMMON ELEMENTS.

Arranged according to Electro-Chemical Order.

	NAME.	SYMBOL.	AT.WT.	VAPOR DENSITY.	STATE.
Negative or Non-Metallic Elements. Acid-Forming with H (usually OH).	Oxygen	O″	16	16	G
	Sulfur	S″ IV (VI)	32	32	S
	Nitrogen	N‴ V, etc.	14	14	G
	Fluorin	F′ (V)	19		G
	Chlorin	Cl′ (V)	35.5	35.5	G
	Bromin	Br′ (V)	80	80	L
	Iodin	I′ (V)	127	127	S
	Phosphorus	P‴ V	31	62	S
	Arsenic	As‴ V	75	150	S
	Chromium	Cr″ ‴ VI	52		S
	Boron	B‴	11		S
	Carbon	C(″) IV	12		S
	Antimony	Sb‴ V	120		S
	Silicon	Si IV	28		S
	Hydrogen	H′	1	1	G
Positive or Metallic Elements. Base-Forming with OH.	Gold	Au(′) ‴	197		S
	Platinum	Pt(″) IV	194		S
	Mercury	Hg′ ″	200	100	L
	Silver	Ag′	108		S
	Copper	Cu(′) ″	63		S
	Bismuth	Bi‴ (V)	207		S
	Tin	Sn″ IV	117		S
	Cadmium	Cd″	112	56	S
	Cobalt	Co″ (‴)	59		S
	Nickel	Ni″ (‴)	58		S
	Lead	Pb″ (IV)	206		S
	Iron	Fe″ ‴	56		S
	Zinc	Zn″	65	32½	S
	Manganese	Mn″ (‴)	55		S
	Aluminum	Al‴	27		S
	Magnesium	Mg″	24		S
	Calcium	Ca″	40		S
	Strontium	Sr″	87		S
	Barium	Ba″	137		S
	Sodium	Na′	23		S
	Potassium	K′	39		S

A ( ) indicates a rare valence. Atomic weights are only approximate.

SOLUTIONS.

For solutions to be used in analysis substances should be C.P., and dissolved in distilled water, the solutions filtered if necessary, and put into, *e.g.*, 500cc bottles placed on convenient shelves for class use. For general reactions, *e.g.*, Exp. 37, commercial compounds may be used. Solutions for the more important solids are given below. Others may be made by mixing say 50g with 500cc of H_2O and filtering. Some few should be saturated (sat.).

NUMBER OF GRAMS OF SOLIDS TO 500cc H_2O.

Acids, etc.	(*a*)	$HgCl_2$	25	Na_2SO_3	100
$AgNO_3$	25 (*b*)	$HgNO_3$	25 (*g*)	NH_4Cl	60
$AlCl_3$	50	KBr	25	$(NH_4)_2CO_3$	125
$AsCl_3$	(*c*)	KCN	50	$(NH_4)_2C_2O_4$	20
$BaCl_2$	50	KCl	25	NH_4NO_3	50
$BiCl_3$	(*d*)	K_2CrO_4	25	$(NH_4)_2S$	(*h*)
$C_{12}H_{22}O_{11}$	sat.	$K_2Cr_2O_7$	25	$(NH_4)_2S_x$	(*h*)
$CaCl_2$	50	$K_4Fe(CN)_6$	40	$(NH_4)_2SO_4$	50 (*i*)
$Ca(OH)_2$	sat.	KI	25	$NiCl_2$	25
$CaSO_4$	" (*e*)	KNO_2	50	$Pb(C_2H_3O_2)_2$	50
$CdCl_2$	25	KNO_3	50	$PbCl_2$	sat.
$CoCl_2$	25	KOH	60	$Pb(NO_3)_2$	50
$CrCl_3$	25 (*f*)	$MgCl_2$	50	$PtCl_4$	(*j*)
$CuCl_2$	25	$MgSO_4$	50	$SnCl_2$	40 (*k*)
$Cu(NO_3)_2$	25	$MnCl_2$	25	$SrCl_2$	50
$FeCl_3$	25	Na_3AsO_3	25 (*c*)	$SbCl_3$	(*l*)
$FeSO_4$	50 (*e*)	NaCl	50	$ZnCl_2$	25
$HNaCO_3$	50	Na_2CO_3	50		
HNa_2PO_4	50	NaOH	60		

(*a*) Use the concentrated acids unless dilute (dil.) are mentioned. Dilute acids (HCl, HNO_3, H_2SO_4) are prepared by adding one volume of concentrated acid to four volumes of water. NH_4OH (if of 26°) should be diluted with three times its volume of water.

(*b*) $AgNO_3$ sol. should not be filtered, nor brought in contact with any organic substance which tends to break it up.

(*c*) $AsCl_3$ sol. may be prepared by adding H_2O to Na_3AsO_3, then adding HCl till effervescence stops.

(*d*) Prepare $BiCl_3$ sol. by adding H_2O to bismuth oxychlorid, BiOCl, then stirring into it HCl. Not a great quantity will dissolve.

(*e*) Some substances decompose, oxidize, or precipitate when left in solution, and these should be prepared only as wanted.

(*f*) $CrCl_3$ may be prepared as follows, as the crystalline variety is rather expensive: To some $K_2Cr_2O_7$ sol., add some HCl (say $\frac{1}{20}$) and a little alcohol. Stir well, boil for some time, then let it stand, when the color changes from red to green, and $CrCl_3$ is formed.

(*g*) Dissolve 25^g of $HgNO_3$ crystals in a mixture of 475^{cc} of H_2O and 25^{cc} of HNO_3. Or it may be made by pouring dil. HNO_3 on more Hg than will dissolve and leaving it in a warm place for 24 hours. A little metallic mercury should be left in the bottom of the bottle.

(*h*) $(NH_4)_2S$. Dilute NH_4OH (*a*), then pass H_2S into 300^{cc} of it *until it is saturated*, then add 200^{cc} of NH_4OH (diluted as before). There is first formed $(NH_4)_2S$ (colorless), then $(NH_4)_2SH$ (yellow). Adding NH_4OH forms $(NH_4)_2S$. Ammonium polysulfid, $(NH_4)_2S_x$, is made by stirring $(NH_4)_2S$ for some time with flowers of sulfur, then filtering.

(*i*) $(NH_4)_2SO_4$ sol. when used to separate Sr from Ca must be very strong.

(*j*) This reagent is very expensive, and is best bought in solution already prepared.

(*k*) $SnCl_2$ forms a basic salt with water alone. Hence the solution must be acidified with considerable HCl. It easily oxidizes, and so pieces of metallic Sn should be kept in the bottle. Even then solutions will not remain very long intact, and they must be made reasonably fresh.

(*l*) Add a little butter of antimony, $SbCl_3$, to water well acidified with HCl, as $SbCl_3$ with H_2O forms SbOCl, which is insoluble.

Cochineal Solution. Grind up a handful of cochineal in a mortar, add water, stir, and filter it.

Litmus Solution. Pulverize litmus cubes, add water, and filter the solution.

Indigo Solution. (Sulfindigotic acid.) Slowly mix and stir 5^g pulverized indigo with 25^{cc} H_2SO_4 (or $H_2S_2O_7$, fuming sulfuric acid) in a beaker immersed in cold water. Cover the beaker, and after 48 hours add 500^{cc} H_2O, stir, and filter.

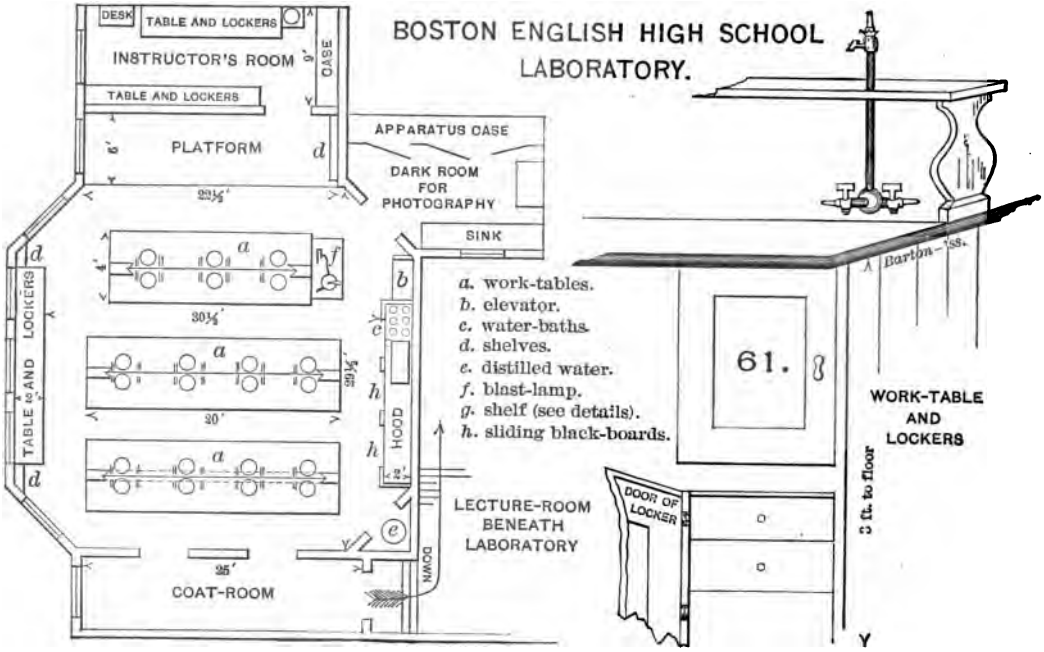
TABLE A. SOLUBILITIES.

Elements.	Acetate.	Arseniate.	Arsenite.	Borate.	Bromid.	Carbonate.	Chlorate.	Chlorid.	Chromate.	Cyanid.	Ferricyanid.	Ferrocyanid.	Fluorid.	Hydroxid.	Iodid.	Nitrate.	Oxalate.	Oxid.	Phosphate.	Silicate.	Sulfate.	Sulfid.
Al'''	S	i	—	i	S	—	S	S	—	—	—	—	i	i	—	S	i	i	i	i	S	—
NH_4'	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	—	S	—	S	S
Sb'''	S	i	i	—	S	—	—	Si	i	—	—	—	S	—	Si	—	i	i	i	—	Si	i
Ba''	S	i	s	i	S	i	S	S	i	s	s	s	i	S	S	S	i	S	i	i	I	S
Bi'''	S	i	—	i	Si	i	S	Si	i	s	—	I	s	i	Si	Si	i	i	i	—	Si	i
Cd''	S	i	—	s	S	i	S	S	i	i	i	—	s	i	S	S	i	i	i	i	S	i
Ca''	S	i	i	i	S	i	S	S	s	S	S	S	i	s	S	S	i	s	i	i	s	S
Cr'''	S	i	—	i	S	—	S	S	i	i	—	—	s	i	S	S	S	i	i	i	S	—
Co''	S	i	i	i	S	i	S	S	i	i	I	I	s	i	S	S	i	i	i	i	S	i
Cu''	S	i	i	i	S	i	S	S	s	i	I	I	s	i	Si	S	i	i	i	i	S	i
H'	S	S	—	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Fe''	S	i	i	i	S	i	S	S	—	i	I	I	s	i	S	S	i	i	i	i	S	i
Fe'''	S	i	i	i	S	—	S	S	s	—	S	I	s	i	S	S	s	i	i	i	S	i
Pb''	S	i	i	i	s	i	S	s	i	i	s	i	s	i	i	S	i	i	i	i	I	i
Mg''	S	i	i	s	S	i	S	S	S	S	S	S	i	i	S	S	s	i	i	i	S	S
Mn''	S	i	i	i	S	i	S	S	s	i	I	i	i	i	S	S	i	i	i	i	S	i
Hg'	s	i	i	—	i	i	S	i	i	i	i	i	S	—	i	S	i	i	i	—	s	i
Hg''	S	i	i	—	s	i	S	S	s	S	—	—	S	—	i	Si	i	i	i	—	Si	i
Ni''	S	i	i	i	S	i	S	S	i	i	I	I	s	i	S	S	i	i	i	i	S	i
K'	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Ag'	s	i	i	i	I	i	S	I	i	i	I	I	S	—	i	S	i	i	i	—	s	i
Na'	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Sr''	S	i	s	i	S	i	S	S	s	S	—	S	i	i	S	S	i	i	i	i	I	S
Sn''	S	i	i	i	S	—	—	Si	i	—	i	i	S	i	S	S	i	i	i	—	S	i
Sn^{iv}	S	i	—	—	S	—	—	S	—	—	—	i	S	i	Si	Si	S	i	i	—	S	i
Zn''	S	i	—	i	S	i	S	S	S	i	i	i	s	i	S	S	i	i	i	i	S	i

S, soluble in water; s, slightly soluble in water; I, insoluble in water and acids; i, insoluble in water, but soluble in acids (HCl or aqua regia) strong or dilute; Si, soluble in water with very little acid.

INDEX TO EXPERIMENTS.

1. Manipulation.
2. Linear Measurements.
3. Volumetric Measurements.
4. Gravimetric Measurements.
5. Glass Working.
6. Glass Bending.
7. " "
8. Stoppers.
9. Physical Division.
10. Chemical "
11. Solution and Crystallization.
12. Union by Heat.
13. Oxygen.
14. " and Carbon.
15. Oxygen and Sulfur.
16. Oxygen and Phosphorus.
17. Oxygen and Iron.
18. Nitrogen.
19. " and Air.
20. Hydrogen.
21. "
22. "
23. Carbon.
24. "
25. "
26. "
27. "
28. Ag and HNO_3.
29. Cu " "
30. Pb and HNO_3.
31. Acids.
32. Bases.
33. Salts.
34. Reactions.
35. Neutralization.
36. Salts from Metals.
37. Insoluble Salts.
38. HCl.
39. "
40. HNO_3.
41. "
42. HF.
43. Aqua regia.
44. H_2SO_4.
45. "
46. NH_4OH.
47. "
48. NaOH, KOH.
49. " "
50. N_2O.
51. "
52. NO.
53. "
54. N_2O_3 and NO_2.
55. CO_2.
56. Flame.
57. "
58. "
59. "
60. "
61. "
62. Chlorin.
63. "
64. Euchlorin.
65. Bromin.
66. Iodin.
67. "
68. Sulfur.
69. SO_2.
70. H_2S.
71. "
72. Phosphorus.
73. Arsenic and Carbon.
74. Reinsch's test.
75. Marsh's "
76. Silica.
77. Oxidation.
78. Reduction.
79. Silver group.
80. Copper "
81. Tin "
82. Iron "
83. Zinc "
84. Barium "
85. Separation.
86. Sodium group.
87. Nitrates.
88. Chlorates.
89. Carbonates.
90. Sulfids.
91. Chlorids.
92. Bromids.
93. Iodids.
94. Sulfates.
95. Phosphates.
96. Conservation.
97. Definite Weight.
98. " Volume.
99. Oxygen, Quant.
100. Hydrogen "


BOSTON ENGLISH HIGH SCHOOL
LABORATORY.
DESK
TABLE AND LOCKERS
INSTRUCTOR'S ROOM
CASE
TABLE AND LOCKERS
PLATFORM
APPARATUS CASE
DARK ROOM FOR PHOTOGRAPHY
SINK
30½'
30½'
30'
25'
COAT-ROOM
TABLE AND LOCKERS
HOOD
DOWN
LECTURE-ROOM BENEATH LABORATORY
a. work-tables.
b. elevator.
c. water-baths.
d. shelves.
e. distilled water.
f. blast-lamp.
g. shelf (see details).
h. sliding black-boards.
61.
DOOR OF LOCKER
WORK-TABLE AND LOCKERS
3 ft. to floor
Barton-ss.

1. MANIPULATION.

Pupils may begin to experiment as follows. The Rules applicable to each case and the cross references in them should first be carefully read.

1. Prepare for experimenting. (Rules 1 and 14.)

2. Light the gas of a Bunsen burner (Rule 13), and note the hottest part.

3. Arrange a ring stand (r.s.) with plate, asbestos board, and flask, and a lamp beneath. (Rule 6.)

4. Arrange a filter stand with funnel and test tube (t.t.), and fold, put in, and moisten a filter paper. (Exp. 9, Fig. 10.)

5. Invert a gas receiver (rec.), filled with water and covered with a glass plate (Exp. 13, Fig. 15), on the shelf of a pneumatic trough (p.t.) nearly filled with water. (Exp. 13, Fig. 14.) (Rule 2.)

6. Hold a glass stopper while pouring a liquid from a bottle. (Rule 9.)

7. Pour a solid — as common salt — from a paper into a dry t.t. (Rule 7.)

8. Pour a liquid from a t.t. (or bottle) into another tube. (Rule 10.)

9. Adjust a t.t. holder of paper, wood, or metal for heating tubes. (Rule 10.)

10. Boil water in a t.t. one-third full. (Rule 12.)

11. Cool a hot liquid in a t.t. under a water jet. (Rule 12.)

12. Invert a t.t. one-fourth full of water, and shake the contents. (Rule 8.)

13. Practise using a stirring rod (s.r.) and a pipette. (Rule 9.)

14. Hold a t.t. or flask, and insert a stopper. (Rule 4.)

15. Examine the names and symbols of the reagent bottles at your bench.

16. Read carefully all the Rules and the Models for taking notes, before the next laboratory period.

2. LINEAR MEASUREMENTS.

Supplies: metric ruler, nickel five-cent piece, foolscap paper.

1. Observe on a metric ruler the length of ten centimeters (10^{cm}).

2. Estimate 10^{cm} by the eye alone on the cover of a book, then verify your result by measurement.

3. Try it with different objects till you can carry 10^{cm} in mind with reasonable accuracy.

4. Estimate the number of inches equivalent to 10^{cm} and verify the result.

5. Measure and estimate 5^{cm} in the same way. Measure the diameter of the older nickel five-cent piece.

6. In the same way experiment with 1^{cm}. Measure the perpendicular distance between the blue lines of foolscap paper.

7. Make a drawing on the opposite page of one square decimeter (1^{qdm}), *i.e.*, a square 10^{cm} on a side. Also of 1^{qcm}.

8. In future experiments, wherever linear measurements are called for, estimates, not measurements, are to be made unless accuracy is desired. Scientific measurements are expressed in the metric system. Commit to memory the following metric tables.

Linear	10 millimeters (^{mm})	= 1 centimeter (^{cm}).
	10 centimeters	= 1 decimeter (^{dm}).
	10 decimeters	= 1 meter (^{m}).
Square	100 square millimeters (^{qmm})	= 1 square centimeter (^{qcm}).
	100 square centimeters	= 1 square decimeter (^{qdm}).
	100 square decimeters	= 1 square meter (^{qm}).

Equivalent 1 inch = $2\frac{1}{2}^{cm}$ (nearly).

3. VOLUMETRIC MEASUREMENTS.

Supplies: graduate, test tubes.

1. Pour from a t.t., into a small graduate (of 25 or 50^{cc}) ten cubic centimeters (10^{cc}) of water, holding it on a level with the eye.

2. Now pour it into a t.t., and note how much of the tube is filled.

3. Empty the tube, then pour in again as nearly 10^{cc} as you can estimate by the eye. Verify your guess by measuring the water.

4. Try this several times, and with tubes of different sizes, until you can estimate quite accurately.

5. Measure and estimate in the same way 5^{cc}. Also 1^{cc}.

6. In future experiments, where volumes are called for, give as close a guess as possible without the use of a graduate, unless special accuracy is required. Liquids and gases are usually measured by volume instead of weight. The pupil should familiarize himself with the following table.

Cubic	1000 cubic millimeters (^{cmm})	= 1 cubic centimeter (^{cc}).	
	1000 " centimeters	= 1 " decimeter (^{cdm}).	
	1000 " decimeters	= 1 " meter (^{cbm}).	

Equivalents	1000^{cc}	= 1 liter (1^{l}).
	1^{l}	= 1 quart (nearly).

4. GRAVIMETRIC MEASUREMENTS.

Supplies: balance, 1^g, 5^g, 10^g weights; common salt, one-cent and five-cent coins.

1. On each pan of a balance put a piece of paper, and when equilibrium is established place a ten-gram (10^g) weight on one pan, and pour fine salt or sugar on the other till equilibrium is restored.

2. Examine carefully the quantity of salt which weighs 10^g, then pour it back into the box. Now take out what you think is 10^g, and verify your estimate by experiment.

3. Repeat the operation several times, or until you can give a reasonably close guess of 10^g of salt.

4. Experiment with 5^g in the same way, then with 1^g. Put as much salt or sugar as you can on a one-cent coin, then weigh it. Weigh the older nickel five-cent piece.

5. In the experiments which follow you are to estimate the quantity of substances named in grams unless weighing is specially asked for. Substances may be either heavier or lighter than salt, but their weight will approximate nearly enough to that of the salt. Solids are usually weighed in grams. Commit the following table:

Weight:

10 milligrams (^{mg}) = 1 centigram (^{cg}).
10 centigrams = 1 decigram (^{dg}).
10 decigrams = 1 gram (^{g}).
1000 grams = 1 kilogram (^{k}).

Conversion:

1^{cc} of water (N. T. P.) = 1^g.
1^l " " " = 1^k.
30^g = 1 oz. (nearly).
1^k = $2\frac{1}{5}$ lb. (nearly).
1^g = 15 gr. (nearly).
1^l hydrogen = $.09^g$ (nearly).

5. GLASS WORKING.

Supplies: glass tubing 20 or 25^{cm} × 15^{mm}, also 20^{cm} × 6^{mm}, Bunsen lamp.

IGNITION TUBES.

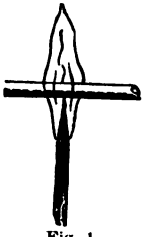


Fig. 1.

Take a piece of ignition tubing 20 or 25^{cm} long, hold it *steadily* in the Bunsen flame *just above the inner greenish cone* (Fig. 1), and rotate it. When it begins to soften draw it out slightly (Fig. 2, *a*) and raise it a little in the flame. Do not pull or twist the glass, but *let the heat gradually separate it*, so as not to have long threads attached. Do not let the hot end of the glass touch any object till it becomes cool. The ends may be rounded (Fig. 2, *b*) by holding and rotating them in the edge of the flame (Fig. 3).

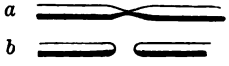


Fig. 2.

Finally anneal the glass by closing the lower openings of the lamp and holding the heated end in the flame to cover it with soot, then letting it cool gradually *without touching any object.* Unless great care is taken in this, the glass will break when next put into the flame. Save the tubes for subsequent experiments.

STIRRING ROD.

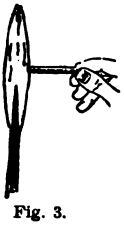


Fig. 3.

Weld the ends of a piece of glass tubing about 20^{cm} long and 6^{mm} in diameter by holding each end successively in a Bunsen flame above the green cone (Fig. 3), and rotating it constantly till the openings are sealed. Use care in cooling it, as before.

6. BENDING GLASS—CONNECTING TUBES.

Supplies: Bunsen burner with attachment, glass tubing 14^{cm} × 6^{mm}, 24^{cm} × 6^{mm} and 40^{cm} × 6^{mm}.

1. For bending glass use the ordinary gas flame (Fig. 4), or a fish-tail attachment to a Bunsen burner, as the Bunsen flame is too hot. Turn down the gas till the flame is about 5^{cm} across. Bend in the middle and at right angles each of 2 or 3 pieces of glass tubing 14^{cm} long, as follows: Take the *ends* of the tube lightly in the fingers and hold the *middle lengthwise in the flame, just above the dark part.* (Fig. 4.) It must be kept constantly in the flame and slowly rotated with the fingers. It will soon be covered with soot and finally begin to soften, the part which is near the middle of the flame yielding first. A slight pressure indicates the softening. When it begins to soften take it quickly from the flame and—holding it between the eye and a window sash or other right angle, with one eye closed—bend it at right angles (Fig. 5). If it does not bend easily, heat it again. *Before wiping off the soot let the tube cool in such a position that the hot portion will not touch any object.* Bend the other short tubes in the same way.

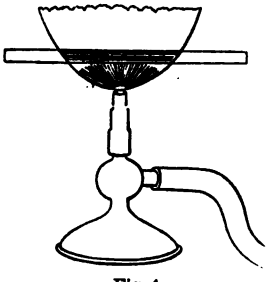


Fig. 4.

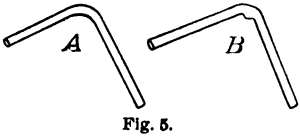


Fig. 5.
A correct. *B* incorrect.

2. Bend at right angles another tube 22 or 24^{cm} long, having the middle of the bend about 6^{cm} from one end (remember that that part of the glass will bend which is in the middle of the flame). Cool this as before. Bend still another tube, 40^{cm} long, 6^{cm} from one end. When the tubes are reasonably cool wipe off the soot with a dry cloth or tissue paper.

3. Round the ends of each tube by holding their tip ends for a minute in a Bunsen flame (Fig. 3), and when they are cool test the result with the fingers. For their use, see Exp. 38, Fig. 32.

7. BENDING GLASS—DELIVERY TUBES.

Supplies: lamp with fish-tail attachment, tubing $50^{cm} \times 6^{mm}$.

1. Examine the angles and the relative lengths of the parts of a delivery tube (d.t.) in a model and in Fig. 6. Note that the parts all lie in the same plane or nearly so (close one eye, and sight along the tube 1, *a*, *b*, *c*, 2); that there are three bends, *a*, *b*, *c*, and that the angles are all obtuse; that *a* and *c* are near the end of the tube (6 or 8^{cm}); that the bends are made in such a way that when the tube is put into a gas gen. (Fig. 19) the end does not touch the bench, nor is it so high as not easily to go under the shelf of a pneumatic trough (p.t.). (Exp. 50, Fig. 38.) In preparing a d.t. pupils must bear all these in mind, and it is often desirable to practise with old glass tubes, especially noting that all parts lie in the same plane. It is better to make two bends at *a*, *b* rather than one, though the two are close together. Make the bends in the order *a*, *b*, *c*, and as follows:

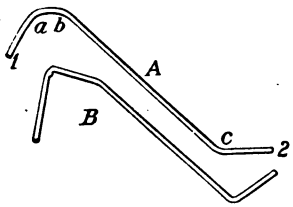


Fig. 6.
A correct. *B* incorrect.

2. Use a piece of tubing 50^{cm} long, and holding the short portion 1 *a* in the right hand, heat it as in Exp. 6, in the fish-tail flame. When it softens take it quickly from the flame and sight along the tube with one eye closed as you bend it. Avoid bending it too much. Bend *b* in the same way, having it close to *a*. As you bend it sight along the parts 1, *a*, *b*, 2. Then bend *c*, holding 2 in the right hand. Sight along 2, *c*, *b*, *a*, 1. Cool it cautiously, as before. Round the sharp ends 1, 2 in the Bunsen flame, as previously. Show the result to the instructor.

8. CORK AND RUBBER STOPPERS.

Supplies: cork stopper, round file, rubber stopper, connecting tubes, thistle tube, test tube.

1. To a t.t. ($5 \times \frac{5}{8}$ or $6 \times \frac{3}{4}$ in.) fit a cork, then remove the latter and with a round file bore a hole through it, holding it in the left hand between the thumb and fingers and pressing the end of the file against the middle of its *larger surface. Observe constantly during the operation whether the file is perpendicular to the surface of the cork.* Make a perfectly circular orifice, reversing the cork so as to have it of uniform bore throughout. The hole must be a little smaller than the tube it is to receive. When the operation is completed put the end of the d.t. (1 *a*, Fig. 6) through the hole, and adjust the stopper to the t.t. Detach the stopper from the t.t., not from the d.t.

2. The app. described above is for use where there are only solids (*e.g.*, Exp. 13). For Exp. 20, in which liquid is employed, a stopper with two openings is needed, one of which is for a thistle tube. For Wolff bottles, (Exp. 38), a third hole for a safety tube is desirable.

3. Rubber stoppers may be used instead of cork, thus saving much time in preparation. To insert a tube in a rubber stopper, *wet both the tube and the orifice of the stopper.* Tubes should be detached from rubber stoppers when you are through using them. Every tube before insertion in a stopper should have had its end rounded in the Bunsen flame (Fig. 3).

9. PHYSICAL DIVISION OF MATTER.

Supplies: test tubes and holder, Bunsen lamp, sugar, stirring rod, filter paper, filter stand, funnel.

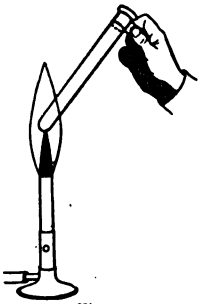


Fig. 7.

1. Put into a t.t. about 5g of sugar. $C_{12}(H_2O)_{11}$, and add about 5cc of water H_2O. (Rule 14.)

2. Use a t.t. holder of wood or metal (paper folded several times serves as well), and hold the tube in the middle of the flame of a Bunsen burner, 5 or 6cm above the lamp, at an angle of about 45° (Fig. 7). Agitate the liquid while it is heating by slightly shaking the tube.

3. Observe and describe the action, and state what it shows. Is there any change seen in the sugar?

4. When there is no more sugar to be seen in the tube, remove the latter from the flame and hold it under a jet of water for a minute to cool the liquid. (Rule 12.)

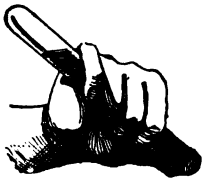


Fig. 8.

5. Taste a drop of the liquid, using for this purpose a clean s.r. Describe, and state your conclusion. What do you learn of the action of water in dividing sugar? (Rule 19.)

6. Divide the sol. into 2 parts, save one for Exp. 10, add to the other its own volume of water, shake it well, (Rule 8, Fig. 8), and taste a drop. Compare the taste with that in 5. What does this indicate of the further division of sugar?

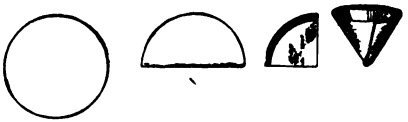


Fig. 9.

7. Fold a filter paper (Fig. 9), pour the sol. upon it (Fig. 10), and catch the fil. in a clean t.t. Does it seem probable that the sugar has or has not gone through the filter paper? What proves this conclusively? Examine filter paper and filtrate.

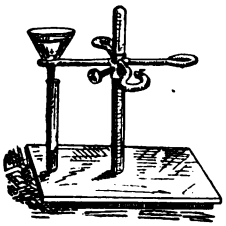


Fig. 10.

8. Are the changes in the sugar in this exp. physical or chemical, and why? (Rule 19.)

10. CHEMICAL DIVISION OF MATTER.

Supplies: sugar solution, sulfuric acid, test tube and holder, evaporating dish, tin plate, ring stand, lamp.

1. (Rule 1.) Take the other half of the sol. (Exp. 9) in a t.t., hold the latter with a tube holder, and slowly pour into the tube a little sulfuric acid, H_2SO_4 (Fig. 11, Rules 9, 10). Watch carefully the result. If there is any action, describe it, see where it begins and how it continues, and give accurately any color changes. Note whether the temperature of the t.t. continues the same. See whether any gas escapes, and take the odor.

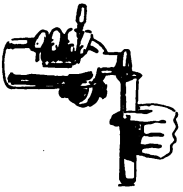


Fig. 11.

2. Add more acid, and note any further changes, especially whether the volume is increased, whether the color changes further, and whether a solid appears. Write an account, covering all these points and any others observed. After writing it compare it with the Model.

3. Explain the causes of the phenomena, remembering that sulfuric acid has great affinity for water, with which it combines, and that sugar is composed of carbon (charcoal) and water. State also whether this is a physical or a chemical change, with the reason for your opinion, and whether molecules have been broken up or built up. (Rule 17.)

Fig. 12.

4. Put a few crystals of sugar into an e.d., and heat them, using a tin plate and asbestos (Fig. 12). See whether the change produced by heat resembles that by the acid, and whether you can detect the constituents of which sugar is composed, viz., carbon and water. (Rule 2.)

11. SOLUTION AND CRYSTALLIZATION.

Supplies: evaporating dish, lamp, ring stand, plate, asbestos, test tubes, cloth, alum, copper sulfate, ferrous sulfate, calcium chlorid.

1. Fill an e.d. $\frac{2}{3}$ full of water, heat it, and add small pieces of alum until the liquid becomes thick. Replace the water lost by evaporation. Now put in a narrow piece of cotton cloth so that it lies in the liquid but does not touch the bottom of the dish, and set the latter aside to cool. Observe it occasionally, meantime doing the following:

2. Cautiously boil about 5^{g} copper sulfate in 5^{cc} H_2O in a t.t. until it is dissolved. Then place the t.t. in an oblique position and let the liquid cool. If necessary, leave it till the next laboratory hour. Note the formation of crystals in 1 and 2, and observe their form, color, luster, angles, etc. Are these illustrations of physical or of chemical changes, and why? Trace each step in the process. Which seems more soluble, alum or sulfate of copper? Are they more soluble in hot or in cold water?

3. Put a crystal of ferrous sulfate and a small piece of calcium chlorid on separate pieces of paper, and leave them in the locker exposed to the air till the next exercise. Describe the result, and ask an explanation.

12. UNION OF ELEMENTS BY HEAT.

Supplies: flowers of sulfur, copper turnings, ignition tube and holder, lamp, tin plate.

1. (Rule 14.) Make a mixture on paper (Rule 7) of sulfur flowers, S, and fine copper turnings (or filings), Cu, about equal bulks of each, and enough in all to fill an i.t. (Exp. 5) not over one third full. Make a crease in the paper, and pour the mixture into the tube.

2. Hold the i.t. with a tube holder of paper, wood, or metal, moving the tube sidewise alternately into and out of the flame for a minute, to prevent breakage, then hold it *steadily* in the middle of the flame, 5 or 6^{cm} above the lamp, at an angle of about 45°, so as to heat the lower part of the mixture first (Fig. 13).

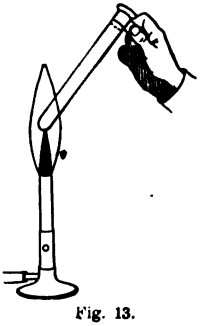


Fig. 13.

3. Look carefully in the mixture for any change which shows a chemical action while it is heating. As soon as you see this change in any portion, take the tube out of the flame for a minute and see whether the change spreads throughout the mass. If not, heat the tube again where the change has not occurred. When you have seen evidence of a chemical change in the entire mass, place the i.t. in a tin plate.

4. (Rule 19.) Describe fully everything about the experiment which seemed interesting, and try to explain why it occurred. What was the vaporous substance which passed out of the tube while it was heating? Did you detect any odor while you were doing the experiment? If so, describe and explain. Especially describe the appearance inside the tube when it was heating.

5. Break the tube (hold it for a minute in the flame, then let 2 or 3 drops of water fall on it from a jet). It can now be easily broken by striking it against the plate. (Rule 11.)

6. Examine the product to see whether it resembles or differs from the original mixture of Cu and S in color, luster, form, etc. Why should it, or should it not? Write an equation to express the change. Notice that heat was the agent in effecting the change.

13. PREPARATION OF OXYGEN.

Supplies: pneumatic trough, ring stand, lamp, test tube and delivery tube, wide-mouth bottles, glass plates, manganese dioxid, potassium chlorate.

1. (Rule 16.) Fill a pneumatic trough (p.t.) with water to 1 or 2^{cm} above the shelf, and put it on one side of the sink. Next, place a ring stand (r.s.) at the end of the p.t. near a lamp (Fig. 14).

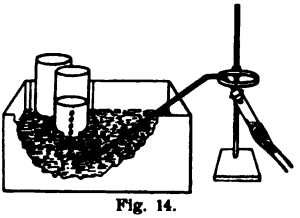


Fig. 14.

2. Fill 4 (or more) wide-mouth bottles (receivers, rec.) with water, and slide a glass plate over each. Take it in the right hand, as in Fig. 15, and invert on the shelf of the p.t., removing the glass.

3. Mix on paper about 5^g of potassium chlorate crystals, $KClO_3$, with 3 or 4^g of black powdered manganese dioxid, MnO_2, and pour the mixture into a large t.t. (Rule 2), which should not be *over* one-third full.

4. Adjust to the tube a stopper with delivery tube (d.t.) (Rule 4), and hang it on the r.s., having the other end of the d.t. under the orifice of the p.t. shelf.

Fig. 15.

5. Light a Bunsen jet and, holding the lamp in the hand, heat the mixture in the t.t. (Fig. 14). Do not heat the t.t. too long in one place or it will melt, but move the flame and take it away for a few seconds after the gas begins to be liberated freely. The first of the gas coming through the orifice is air. After a minute, move a rec. over the orifice and collect the gas. Fill also the other recs. Watch for any action in the tube, and see how the gas rises in the recs. Describe, and give equation. As soon as the recs. are full and the heat is removed, take the d.t. out of the p.t. (but let it hang on the r.s.), or water will draw back and break the tube.

6. The recs. may be taken out as soon as filled, first sliding the glass plates under them, and leaving them covered, or they may better be left in the p.t. till wanted in Exps. 14–17, after which the t.t. can be cleaned by adding water when the tube is cool, and shaking it.

7. Take full notes (Rule 17). State what substances are left in the tube

14. CARBON AND OXYGEN.

Supplies: oxygen, splint, lamp, lime water.

1. Remove the recs. of oxygen from the p.t., placing them upright and covering them with glass plates (Fig. 16). Use one rec. for each of Exps. 14–17.

2. Light one end of a splint and instantly thrust it into a rec. of oxygen, removing the glass plate for the purpose. See whether it burns more or less vigorously than in the air. Take it quickly out, blow out the flame, and thrust the glowing end again into the gas. What happens? Repeat this several times in rapid succession. What appears to be left in the rec.? Note any color to the flame. Was there any explosion?

Fig. 16.

3. Wood consists in part of compounds of carbon. This carbon combined with the oxygen to form carbon dioxid. Supposing the element carbon to be free, write the equation to show its chemical union with oxygen. (Rule 20.)

4. Note that flame is not a material substance, but simply a phenomenon which accompanies certain chemical union. The *product* of the combustion or union of carbon and oxygen is an invisible gas. Its presence can be detected by pouring a little lime water into the rec. and shaking it up well, when a white, turbid liquid appears, showing a solid that is not dissolved. Any white substance seen after the burning of the splint was probably unburned, finely divided carbon (*i.e.*, smoke).

15. SULFUR AND OXYGEN.

Supplies: oxygen, sulfur, combustion cup, lamp, potassium dichromate solution.

1. (Rule 14.) Make a slight depression with a knife in one end of a crayon or an electric-light pencil (2 or 3^{cm} long), and wind around it tightly two or three times a small copper wire (2 or 3^{dm} long). This makes a combustion cup. Prepare a rec. of oxygen (Exp. 13).

2. Hold this cup by the wire in the left hand, and put into the cup a piece of sulfur (brimstone) as large as a grain of wheat. Take the Bunsen lamp in the right hand and direct the flame against the sulfur. When the latter is burning, lower it into a rec. of oxygen (Fig. 17).

Fig. 17.

3. Note the color of the flame, the vigor of combustion as compared to its burning in air, and the color of the product (which should be kept mostly in the rec.). Does the product seem to be a gas or a solid? Very cautiously try the odor (Rule 17). The product is sulfur dioxid. Explain what has taken place chemically (of which the flame was an indication), and give the equation.

4. The product may be tested by putting a drop of potassium dichromate solution on a piece of paper and lowering it into the receiver, when the red liquid will soon be changed to green. This is a test for sulfur dioxid. Should the sulfur dioxid weigh more or less than the orginal sulfur, and why?

16. PHOSPHORUS AND OXYGEN.

Supplies: oxygen, phosphorus, lamp, combustion cup, wire, litmus solution.

Caution. Phosphorus should not be handled except under water, as burns from it are severe, and slow to heal. It must never be left exposed to the air, for it takes fire at a low temperature. Always carry it in an e.d., use only very small pieces, and burn it all at last.

1. Have a rec. of oxygen (Exp. 13) covered with a glass plate, and a combustion cup (Exp. 15). Put into an evaporating dish (e.d.) with the forceps a piece of phosphorus half as large as a pea. Remove any adhering water by rolling it lightly on paper, then place it with the forceps in the combustion cup held by the wire in the left hand. Take another wire (or the handle of a file) in the right hand and just bring it in contact with a Bunsen flame, then touch the phosphorus with the warm metal. If it does not take fire, repeat the operation, then lower it at once into a rec. of oxygen, nearly covering the latter with a glass plate.

2. Notice the color of the flame and its intensity as compared with the burning of P in air. What does the difference indicate? See what you can determine of the product — its color, odor, state (whether solid, liquid, or gas), etc. See whether it changes on standing, and in what way. Explain the chemical action of the combustion of P, and write an equation. The product is phosphorus pentoxid, P_2O_5.

3. Burn all the phosphorus from the cup by holding it for some time in a Bunsen flame.

4. Shake up the product in the rec. with 3 or 4^{cc} of blue litmus sol. and state the result. This shows that an acid (phosphoric acid) has been formed by adding water to P_2O_5. (Rule 20.)

17. IRON AND OXYGEN.

Supplies: oxygen, picture wire, sulfur, lamp, forceps.

1. This experiment is liable to crack the rec. containing the gas, hence either an old bottle (rec.) may be used, or 3 or 4^{cm} of water should cover the bottom. Sand is often used for this purpose. In either case a large-sized rec. is desirable.

2. Crush on the bench a piece of sulfur (about the size of a grain of wheat) with the handle of your forceps.

3. Take one end of a picture wire (8 or 10^{cm} long) in the forceps, just bring the other end to a flame, then dip the warm wire into the crushed sulfur, so that a little may adhere to the wire, bring it again for an instant to the flame, then, if the S burns, quickly thrust it into the rec. of oxygen and hold it there.

4. The S should first burn, then the wire. If not successful, try it again. Only a little S should be used. Watch carefully the combustion (the iron is said to burn with scintillation), *describe it*, and see whether you can detect a flame. The product is a solid, iron tetroxid, Fe_3O_4. Write an equation to express the chemistry of the combustion. (Rule 15.) Should you think the oxid of iron formed would weigh more or less than the iron which was burned, and why? In Exps. 14–17 different substances burned in oxygen. These substances were therefore called *combustibles*, and oxygen is called a *supporter of combustion*.

18. NITROGEN FROM AIR.

Supplies: wide-mouth bottle, combustion cup, phosphorus, wire, lamp, glass plate.

1. (*Caution*, Exp. 16.) Fill a p.t. with water to about 2^{cm} above the shelf.

2. Put the wire of a combustion cup through the orifice in the shelf (Fig. 18) so as to have the bowl of the cup reach half-way to the top of an inverted rec. placed over it, and bend the end of the wire over the side of the p.t. to fasten it, and have it easily removable. The mouth of the rec. when inverted over the cup will be under water, and a portion of air confined in the rec.

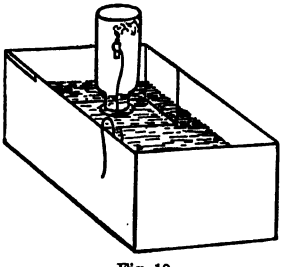


Fig. 18.

3. Take a piece of phosphorus, P (the size of half a pea), using forceps and an e.d., and place it in the cup.

4. Take another wire (or a file) in the left hand and an inverted rec. in the right, *just warm* one end of the wire by touching it to a Bunsen flame but not holding it there. Touch the P with it, then instantly invert the rec. over the P, and *hold it steadily in position.* See whether any air is forced out.

5. Watch the combustion, note the color and strength of the flame, and the color, state, etc., of the product. Explain fully what is taking place, and write an equation. Note any change in the level of the water in the rec., and explain; also any change in color. See whether you can determine what becomes of the product of combustion. (Rule 19.)

6. When the contents of the rec. become tolerably clear, remove the cup without disturbing the rec. or admitting air. *Burn all the P by holding the spoon in a Bunsen flame.*

7. Remove the rec., using a glass plate, leaving it right side up with the water in the bottom, and keeping the gas covered for Exp. 19.

19. NITROGEN AND AIR.

Supplies: nitrogen, splint, match, litmus paper, graduate.

1. Thrust a burning splint into a rec. of nitrogen (Exp. 18), sliding along the glass plate enough to admit it. Observe the effect. Try this with a glowing splint.

2. See whether the P and S on the end of a match will burn in the gas. Is N a supporter of ordinary conbustion? A combustible? Should there be an equation for these experiments? Why?

3. Drop a piece of blue litmus paper into the liquid in the rec., note the effect, and explain if possible (Exp. 16).

4. Find the per cent of O and N by volume in the air as follows: Measure in a graduate the volume of water in the rec., from Exp. 18, and record it here.....cc. Then fill the same rec. full of water, and measure its total capacity.....cc. What part of the air does the former represent? The latter? Now, compute the per cent of O in air; the per cent of N (give the entire work). This ought not to vary much from 20% for O and 80% for N. In case you get above 25% for O, or below 15%, the Exp. should be done again. State anything which would be likely to vary the result on either side. From the per cent of nitrogen obtained there should be subtracted 1% for the newly-discovered element argon, A.

20. PREPARATION OF HYDROGEN.

Supplies: gas generator, pneumatic trough, receivers, glass plates, zinc, hydrochloric acid.

1. (Rule 16.) Prepare a hydrogen generator (gen.) as follows: Use a wide-mouth bottle with tight-fitting stopper (preferably rubber) having two holes. Into one of these insert a d.t. (Exp. 7), and into the other a thistle tube (Fig. 19). (Rule 4.) Also prepare a p.t., with water 1 or 2^{cm} above the shelf, and fill and invert several recs., as in the oxygen exp. (Rule 3.) Fill one rec. half full of water, let air fill the other half, and finally fill the part containing water with hydrogen, as below.

Fig. 19.

2. Put into the gen. 10 or 12^{g} of zinc, add water to a depth of 3 or 4^{cm}, insert the stopper (see that the end of the thistle tube is under water), and pour through the thistle tube 3 or 4^{cc} of hydrochloric acid, HCl. Put the end of the d.t. under the orifice in the shelf, and after half a minute move one of the recs. over the orifice and collect the gas. Fill each rec. with hydrogen, adding more HCl as may be needed, but avoid excess. No heat is applied. Leave the recs. of H on the shelf till wanted in Exps. 21, 22. If taken out, they must be kept inverted (Fig. 20), covered with glass plates.

Fig. 20.

3. Watch closely the action in the gen. and describe it. It is called effervescent action. See whether the gas which collects is clear and colorless or not. Try to see everything, and learn all you can from the exp. Notice the rise and fall of the liquid in the thistle tube and account for it. Any floating particles are likely to be impurities in the zinc. The chlorin of the acid leaves the hydrogen and combines with the zinc, forming zinc chlorid, $ZnCl_2$. Give an equation to express this action. Water takes no part in the reaction, but is used to dissolve the $ZnCl_2$. From what does the hydrogen come?

4. After doing Exp. 21, take apart the gen., remove the tubes from the stopper (wash them), and return the apparatus. Pour the liquid down the sink (open the jet), and rinse the remaining zinc and put it back into the box.

21. COMBUSTION OF HYDROGEN.

Supplies: hydrogen, splint, lamp.

1. Light a splint in the flame, holding it in the right hand, and with the left lift a rec. of hydrogen gas (Exp. 20) from the p.t., keeping it inverted. Bring the burning splint to the mouth of the inverted rec. and take note of what happens (Fig. 21). Look closely for any flame in the rec., gradually turn the latter right side up and look down into it. See whether anything appears to collect on the sides of the rec., and if so, describe and account for it. Is H a combustible (*i.e.*, does it burn)?

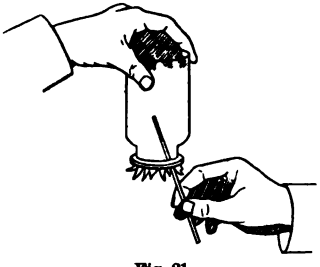


Fig. 21.

2. Try the same exp. again, using another rec. of H, but this time thrust the splint up into the gas, and note whether the splint still burns, or the flame is extinguished. Observe the other phenomena as before, looking especially for anything on the sides of the rec., and note, as you look down into the open rec. while the gas burns, how many colors the flame has, and what is the position of the colors as regards each other. Do it over again, if you are not satisfied with the results. What product would you expect to result from this exp.? Is there any evidence that such a product is formed? Write an equation to express this. Is hydrogen a supporter of carbon combustion, as shown by this exp.? If an explosion ensued in any of the above exps., try to explain it.

3. Bring the rec. which contains the mixture of half air and half H to a Bunsen flame. Describe, and explain the result. What was the supporter of combustion in this case? An explosion is caused by bringing a flame in contact with an intimate mixture of a combustible and a supporter of combustion.

22. EXPERIMENTS WITH HYDROGEN.

Supplies: hydrogen, receiver, philosopher's lamp, test tube, wide glass tube, ring stand.

1. Try to pour hydrogen upward as follows. Hold in the left hand an *inverted* empty (*i.e.*, filled with air) rec., and take an inverted rec. of hydrogen in the right, and gradually but quickly turn the latter so as to bring its mouth under that of the former (Fig. 22) in such a way that the two gases may change places. Now after two or three seconds bring each, one at a time, to the flame. Describe your result, and state what property of H it illustrates.

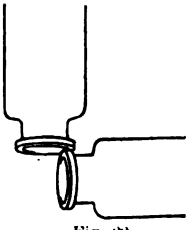


Fig. 22.

2. Collect a rec. of hydrogen by upward displacement, as follows: In place of the d.t. of the gen. (Exp. 20) insert a tube, which should reach nearly to the top of an inverted rec. (Fig. 23). The air will be forced down by the lighter gas. After generating the gas a minute try to explode the H.

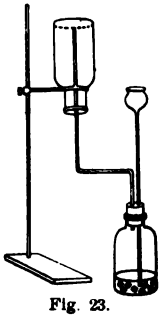


Fig. 23.

3. Make a philosopher's lamp. To do so, remove the d.t. from the gen. (Exp. 20) and insert a capillary tube (Fig. 24). Generate hydrogen as in Exp. 20, and before trying to light the gas, collect a t.t. full by upward displacement, and explode it. If a sharp sound is heard, the air has not been expelled, and to light the gas would make a dangerous explosion. If there is scarcely any sound, or a light muffled one, the escaping gas may be lighted. Note the color of the flame. To ascertain the product, hold the mouth of a dry t.t. or bottle just over the flame for some time, or, better, hold a tube open at both ends over the flame, and look for any deposit. If the tube is long enough, a musical note may be heard, due to the vibration of the column of air in the tube.

Fig. 24.

23. CARBON FROM WOOD.

Supplies: Hessian crucible, sand, wood, ring stand, lamp.

1. Put into a small Hessian crucible (2 × 3 in.) 6 or 8 small pieces of wood (*e.g.*, $\frac{3}{4} \times \frac{1}{2} \times \frac{1}{4}$ in.).

2. Just cover them with sand.

3. Put the crucible into an iron ring (2 in. in diameter) attached to a ring stand.

4. Slide the ring on the r.s. till the bottom of the crucible is within 1 or 2^{cm} of a Bunsen burner placed beneath (Fig. 25).

Fig. 25.

5. Light the gas, and, while the wood is undergoing distillation, do Exp. 24, but keep watch of the contents of the crucible to see whether any gases rise. If so, note the color, the odor, and whether they will burn or support combustion.

6. When gases stop rising — the wood should not be heated over half an hour — remove the lamp, and pour the contents of the crucible into a tin plate (leave the hot crucible in the ring, and remove the latter from the r.s. with a towel).

7. Examine the sand to see whether there is evidence of a liquid having been liberated.

8. Compare the residual coal with the original wood as to color, porosity, weight, volume, brittleness, combustibility. See whether it burns with a flame. Explain. What evidence that it burns at all? Describe any residue. Save the rest of the coal, and return the sand. Is carbon a combustible substance, or a supporter of combustion, or neither?

9. To remove the crucible from the ring, strike the bottom of the former squarely upon the floor.

24. CARBON FROM GAS, OIL, PARAFFIN.

Supplies: Bunsen lamp, oil lamp, candle, glass tube or crayon.

1. Close the basal orifices of a Bunsen burner with the fingers, or by turning the attachment.

2. Hold in the upper part of the flame one end of an old piece of glass tubing or of crayon. If any deposit appears, examine it and state its origin.

3. Open the basal orifices, and see whether the deposit can be burned off in this latter flame. Explain fully, stating which flame is the hotter of the two, and why. (Rule 19.)

4. Collect a little carbon in a similar way from the flame of a kerosene lamp.

5. Collect some also from a candle flame.

6. Gas, oil, and paraffin consist mostly of compounds of carbon and hydrogen, called hydrocarbons. These may be solid, liquid, or gaseous. What two products, at least, would result from their combustion? Explain why carbon deposits from each of the above three sources.

7. See whether this experiment teaches you why the flame of a gas jet, or of a lamp or candle, sometimes smokes.

25. REDUCING ACTION OF CHARCOAL.

Supplies: Copper oxid and charcoal, ignition tube, lamp, nitric acid, filter paper, filter stand, funnel.

1. Put into an i.t. (Rules 7 and 2) an intimate mixture of copper oxid, CuO, and powdered charcoal, C. Do not fill the tube more than one-fifth full.

2. Heat the *lower part* of the mixture (Rule 13) in a Bunsen flame till you see evidence of chemical action. Look carefully for this action, state where it begins, how it progresses, and what it shows. As soon as it begins, remove the tube from the flame and see whether it spreads to other parts of the substance. If not, hold the tube again in the flame, directing the latter against that part which has not been changed.

3. Heat it for a minute or two after all action ceases, then pour the contents into a tin plate, and compare the product with the original mixture as to color, luster, form, and quantity.

4. State what are the factors and what the products in this experiment. What has become of each product?

5. Write two equations for the action.

6. Test the residue for metallic copper by putting some of it into an e.d., and adding 1 or 2^{cc} of nitric acid, HNO_3. If any fumes arise, note their color and (cautiously) their odor.

7. Add 2 or 3^{cc} of water to the residue in the e.d., and filter it, noting the color of the filtrate. Explain, with equation for the action of HNO_3 on Cu. How could you get the solid compound of copper out of solution?

8. Explain how this shows that Cu has been separated from CuO, and that C is a deoxidizing agent. (Rule 11.) Before the next laboratory hour, ascertain what large industry depends on this property of carbon.

26. DECOLORIZING ACTION OF CARBON.

Supplies: bone black, solutions of cochineal, litmus, indigo, and potassium dichromate, filtering apparatus, test tubes.

1. Put into a t.t. (Rule 7) 5 or 10^g of bone black, C.
2. Add (Rules 10, 9) 10 or 15^{cc} of cochineal sol.
3. Cover the mouth of the tube with the thumb or a stopper, and shake the mixture thoroughly for a minute. (Rule 8 and Fig. 26.)

Fig. 26.

4. Pour the contents upon a filter, and catch the filtrate in a clean t.t.
5. Note whether any color remains in the filtrate. If not, explain. If so, shake it up again, and longer than before, with more bone black.
6. In the same way as above try the action of bone black on litmus sol. (or a sol. of indigo).
7. Try the action of bone black on potassium dichromate solution, $K_2Cr_2O_7$.
8. Cochineal is an animal pigment, litmus and indigo are vegetable, and $K_2Cr_2O_7$ is mineral. From which of the above classes does bone black seem to remove the color ?
9. Note that bone black is the best decolorizing form of carbon, and ascertain in what large industry it is employed for this purpose.

27. DISINFECTING ACTION OF CHARCOAL.

Supplies: powdered charcoal, hydrogen sulfid sol., filtering apparatus, test tubes.

1. Put into a t.t. (Rule 2) 5 or 10^g of powdered charcoal.

2. Add to this 10 or 15^{cc} of a sol. of hydrogen sulfid, H_2S. Note the odor of the sol.

3. Cover the mouth of the tube with the thumb (Fig. 26) or a stopper, and shake it vigorously (Rule 8) for a full minute.

4. Pour the contents upon a filter (Fig. 10), and catch the filtrate in a clean t.t.

5. See whether the filtrate retains the orginal odor. If so, try the experiment again more carefully. See whether the residual charcoal on the filter has any odor.

6. What property of charcoal does this exp. show? Ascertain a use of carbon dependent upon that property.

28. AFFINITIES—SILVER AND NITRIC ACID.

Supplies: silver coin, copper wire, nitric acid, evaporating dish, test tubes, lamp.

1. Put into an evaporating dish a 10-cent silver coin (or other piece of silver) (Rule 3), and add 1 or 2^{cc} of nitric acid, HNO_3.

2. Warm this over a lamp (using plate and asbestos, Fig. 27) till fumes begin to appear, then remove the lamp.

3. Describe the action, noting the color and odor of the fumes, color of the liquid, and whether any crystals form. What has dissolved, and what has been formed? Write the equation. If there are crystals, describe them.

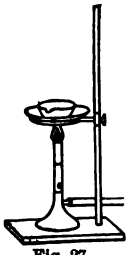


Fig. 27.

4. When all action stops, add 10 or 20^{cc} of H_2O, stir it, filter if the liquid is not clear, and pour it into a clean tube.

5. State what the solution contains, and explain the color. See whether the color changes after doing 6, and explain.

6. Put a bright copper wire (No. 12) into the solution (Fig. 28), and observe. Leave this till you have done Exps. 29, 30, then study the deposit carefully. What is it, and what caused it to be deposited? Note the color of the liquid. What does it contain?

7. Pour the contents of the tube into an evaporating dish, and take out the wire, leaving the deposit in the dish. Is the deposit compact or porous? State color, luster, etc. (A single specimen may be placed under the microscope for the class to examine the crystals.) See whether the wire has changed in size at all. Return the wire. Explain all your observations, and write an equation.

Fig. 28.

8. Wash the deposit by pouring H_2O over it, stirring and then decanting, *i.e.*, pouring off the liquid and leaving the residue. Save the latter (put it in the receptacle marked "Silver Waste").

9. Which of the elements Ag or H seems to have the stronger affinity for NO_3, as shown by this exp.? Ag or Cu? How is silver nitrate solution made? How may crystals of pure silver nitrate be obtained from coin silver?

29. AFFINITIES—COPPER AND NITRIC ACID.

Supplies: sheet copper, lead wire, nitric acid, evaporating dish, test tubes, lamp.

1. Put a strip of sheet copper (*e.g.*, 1×2^{cm}) or a few copper turnings into a clean evaporating dish, and add 1 or 2^{cc} of nitric acid, HNO_3. No heat need be applied.

2. Observe, as in Exp. 28, all phenomena, and explain, giving equations. Dip a splint into the sol. and hold it in a flame.

3. When chemical action stops, or the copper has all dissolved (there should be very little free nitric acid left), add 10 or 20^{cc} of H_2O, filter the liquid if it is not clear, pour the latter into a clear tube and just *warm*, but do not boil it.

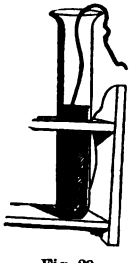


Fig. 29.

4. Put into the liquid a bright lead wire (No. 12, Fig. 29). Pb can be made bright by filing off the surface coating of oxid. If no action is seen, warm the solution again.

5. Watch the action. If bubbles arise, note carefully their origin. If a deposit takes place, see where it occurs and, if possible, what it is. Explain why the action has taken place, and note the character of any gas that comes off. Write the equation.

6. Leave the tube and contents till you have done Exp. 30, then pour the contents into an evaporating dish, remove the deposit from the lead (return the latter), wash the deposit (Exp. 28), and try further to identify it, by the color, luster, etc. Did the solution change color after the Pb was put in? If so, how and why? Was the size of the wire changed? Explain. Was the deposit crystalline or amorphous? Try the action of a drop or two of HNO_3 on it.

7. How is nitrate of copper solution made? What is its color? How obtain the solid from the solution? Does the exp. show whether copper nitrate is soluble in water? Which metal, Cu or Pb, has the stronger affinity for nitric acid (or NO_3), and how does this exp. show it?

30. AFFINITIES—LEAD AND NITRIC ACID.

Supplies: lead, zinc wire, nitric acid, evaporating dish, test tubes, lamp.

1. Place a small piece of lead (1^{qcm}), made bright by filing, into a clean e.d. and add 1 or 2^{cc} of HNO_3 mixed with the same volume of H_2O.

2. Warm it over a flame, using plate and asbestos (Fig. 27), till vigorous action ensues, then take away the lamp and watch the action.

3. Describe all phenomena as fully as in Exps. 28, 29.

4. When the action fully stops (there should be very little free acid) add 10 or 20^{cc} of H_2O, stir it well, take out the remaining lead, filter if the liquid is not clear, and put in a bright piece of zinc wire ($\frac{1}{8}$ in. diam.) or other piece of Zn.

5. Watch carefully the phenomena. If much free acid is present, violent effervescence will ensue and both metals may dissolve. Look for any products and describe their appearance. Give the equation.

6. Finally remove with water and the hand any of the product that adheres to the Zn, saving the latter.

7. What is the deposit supposed to be? Describe its color and appearance. Is it crystalline? (Examine in direct sunlight.) What is now in solution? Explain fully, with equation. How may soluble nitrates be made? See (Table A) whether any nitrates are insoluble. Do Exps. 28–30 illustrate physical sol., or chemical sol., and why?

8. Place these elements in a vertical column (with a minus sign — at the top and a plus sign + at the bottom) in the order of their affinities for NO_3, as shown by Exps. 28–30, the one with least affinity at the top: Pb, H, Zn, Ag, Cu.

31. ACIDS.

Supplies: HCl, HNO_3, H_2SO_4, blue litmus paper, e.d., s.r.

1. Pour into a clean e.d. *a few drops* of hydrochloric acid, HCl (Rule 9), add 1 or 2^{cc} of H_2O, stir it well, and taste a drop from the s.r. (Fig. 30). State what the taste is.

Fig. 30.

2. Dip the tip end of a piece of blue litmus paper into the sol. and record the effect.

3. Rinse the e.d. 2 or 3 times, then pour in *a few drops* of nitric acid, HNO_3, and 1 or 2^{cc} of H_2O. Stir it and taste a drop, using the s.r. Test it with the end of blue litmus paper.

4. Rinse the e.d., and taste and test in the same way *a few drops* of sulfuric acid H_2SO_4, diluted with 1 or 2^{cc} of H_2O.

5. Make a record of all your results and state two properties of an acid. Notice whether the symbols of these three acids have any element in common, and whether the right hand part of the symbol is metallic or non-metallic.

6. What other property of certain acids is shown by Exps. 20, 28, 29, 30, 36?

32. BASES.

Supplies: NH_4OH, KOH sol., NaOH sol., red litmus paper, e.d., s.r.

1. Pour into a clean e.d. about 1^{cc} of ammonium hydroxid, NH_4OH, add 1 or 2^{cc} of H_2O, stir it, and taste a drop from the s.r.

2. (Rule 9.) Dip into the sol. the tip end of a piece of *red* litmus paper.

3. Rinse the e.d. and taste and test with litmus, in the same way as above, a sol. of sodium hydroxid, NaOH, diluted with its own volume of water.

4. Taste and test in the same way potassium hydroxid sol., KOH.

5. State your conclusion in regard to the action of bases. Notice whether the symbols of these bases have any common elements, and whether the left-hand part of the symbol is metallic or non-metallic. Compare the action of acids and bases. Compare their composition. Exp. 35 shows another property of acids and bases.

33. SALTS.

Supplies: solutions of NaCl, KNO_3, $(NH_4)_2SO_4$, Na_2CO_3, $HNaCO_3$, $HKSO_4$, e.d., s.r., red and blue litmus papers.

1. Pour into a clean e.d. 1 or 2^{cc} of sodium chlorid sol., NaCl, taste a drop of it from the s.r., and test its action on both red and blue litmus.

2. Test in the same way a sol. of potassium nitrate, KNO_3.

3. Test also ammonium sulfate sol., $(NH_4)_2SO_4$.

4. State your conclusions as to the usual action of salts on litmus. Of what two classes of elements are salts composed? (Exps. 28–30.)

5. Test the action of sodium carbonate sol., Na_2CO_3, on both red and blue litmus.

6. Try also bicarbonate of sodium sol., $HNaCO_3$.

7. Try also hydrogen potassium sulfate sol., $HKSO_4$.

8. Can you see any reason for the action of the last three? Are all salts neutral? Do all have a saline taste, *i.e.*, a taste like common salt, NaCl? How could you recognize a salt? How the symbol of a salt? Ascertain what these are: normal salt, acid salt, basic salt, neutral salt, salt with alkaline reaction, salt with acid reaction.

34. ACID, ALKALINE, AND NEUTRAL REACTIONS.

Supplies: litmus sol., HCl, HNO_3, H_2SO_4, NH_4OH, KOH sol., NaOH sol., NaCl sol., e.d., test tubes, s.r.

1. Pour into a t.t. or small beaker about 5^{cc} of blue litmus sol. (Rule 14.)

2. Into an e.d. pour a few drops of hydrochloric acid, HCl. Now dip a s.r. into this HCl (Rule 9), and stir with it the litmus sol. for an instant. A single drop of acid will thus be left in the litmus sol. Notice the result. *Should there be no effect,* add another drop of HCl with the s.r. in the same way. The result shows an acid reaction. Save the sol.

3. Rinse the e.d., and pour into it a few drops of ammonium hydroxid, NH_4OH. Dip the s.r. into this and then into the same litmus sol. If the latter shows no change in color, repeat the operation. It should now indicate an alkaline reaction.

4. Again rinse the e.d., put in a few drops of nitric acid, HNO_3, and dilute with the same volume of water. Stir a drop of this (using the s.r., as before) into the same litmus sol. If necessary, repeat till an acid reaction is observed.

5. Now stir into the sol. a drop of sodium hydroxid sol. from the e.d., repeating, if necessary, till an alkaline reaction is obtained.

6. In the same way, obtain an acid reaction with sulfuric acid, H_2SO_4, which has been diluted with the same vol. of water.

7. Restore the original color with a drop (or more) of potassium hydroxid, KOH.

8. Divide the litmus sol. into two parts. Acidify one with a drop or two of any acid. To each of the sols. add a little NaCl sol. Add H_2O. Explain.

35. SODIUM CHLORID BY NEUTRALIZATION.

Supplies: beaker, test tubes, e.d., s.r., HCl, NaOH sol., ring stand, tin plate, asbestos, lamp.

1. Pour into a t.t. (or beaker) 10cc of sodium hydroxid sol., NaOH, and into another t.t. 5 or 10cc of hydrochloric acid, HCl.

2. Pour about half the NaOH sol. into a clean e.d. Now take the t.t. of HCl in the right hand and pour a little of the acid into the alkali in the e.d., resting the lip of the tube on the s.r. to regulate the quantity (Fig. 31). Stir it for an instant with the s.r., then dip into the liquid the tip end of a piece of blue litmus paper. If the latter is not reddened, add a very little more HCl, stir and test it again. If the litmus turns red, add a little NaOH sol. in the same way, stirring and testing it. If it now turns blue, add a drop or two of HCl, *dipping the s.r. into the sol. containing the acid and stirring the liquid in the e.d. with it.* Continue this process with acid and alkali, testing the result with red and blue test papers, until the sol. is neutral, *i.e.*, will not affect either. Observe also the color of the liquid and whether any ppt. seems to form, or heat to be liberated. When very nearly neutral, immerse a piece of test paper in the liquid of the e.d., and touch it with a drop of acid or alkali (as the case may be) on the s.r., and watch the effect.

Fig. 31.

3. When the sol. seems to be neutral, after standing for a minute or two, take it — with both colors of test paper immersed — to the instructor for approval.

4. If the e.d. is more than a quarter or a third full, pour off the rest, and if the liquid is not clean and clear, filter it.

5. Wipe off the outside of the e.d., and place it with the neutralized sol. on an asbestos card and tin plate, put the whole on a large ring of a r.s. (Rule 6), light the gas, and evaporate the liquid.

6. Explain fully what the chemical action has been, and write an equation to express it. What is the object of evaporation?

7. Examine and taste the residue after evaporation, and state what it is. Is any salt probably formed before neutralization is complete? State any evidences this experiment gives of a chemical change.

36. SOLUBLE SALTS FROM METALS.

Supplies: Cu, HNO_3, NH_4OH, H_2S, Zn, HCl, Fe, H_2SO_4, e.d., s.r., filtering apparatus.

1. Put into an e.d. about a gram of copper filings, or sheet copper, and pour over them 2 or 3^{cc} of nitric acid, HNO_3. Observe the action and all the products, liquid or gaseous, and write the equation. How many and what substances are shown by the equation to be formed? State what evidence you have that any of them are formed.

2. Heat the liquid for a minute, using r.s., plate, and asbestos, then remove the flame, and when action stops between the Cu and HNO_3 add 5^{cc} of H_2O, stir it, and pour the liquid into a t.t. (filter it if not clear), leaving any Cu. Has the latter diminished in volume? If so, what has become of it? Is this exp. an example of physical or of chemical solution, and why?

3. Can you state how dissolving a metal in an acid differs from dissolving a salt (*e.g.*, NaCl) in water? What salt is formed in 1 and 2?

4. Divide the liquid (from 2) into two parts. To one in a t.t. add 1 or 2^{cc} of ammonium hydrate, and to the other a little H_2S sol. (or H_2S gas). Describe the effect in each case, and write the equation for the last. Each is a test for copper.

5. Rinse the Cu 3 or 4 times and return it.

6. Put a little Zn into a t.t. and cover it with water, then add a little HCl. What salt will be formed? How can you obtain it in the solid state? Is it soluble? Make $FeSO_4$ from iron. Take full notes of the exp.

37. INSOLUBLE COMPOUNDS BY PRECIPITATION.

Supplies: as below.

1. *To make an insoluble compound, mix two solutions, one of which contains the positive and the other the negative part of the insoluble compound wanted, and the substance will always be precipitated.* This is Berthollet's Law of Precipitation.

2. The following compounds are insoluble. Make each by the application of the above principle (refer to Table A). Fill the accompanying blanks, and write the equations on the opposite page.

Compound Wanted.	Soluble Positive Compound.	Soluble Negative Compound.	Color of Precipitate.
1. $BaSO_4$			
2. $PbCl_2$			
3. $Fe(OH)_3$			
4. $Fe(OH)_2$			
5. $FeIO_4$			
6. CaC_2O_4			
7. $Cu_3(AsO_3)_2$			
8. $PbCrO_4$			
9. Sb_2S_3			
10. $Al(OH)_3$			

38. HYDROCHLORIC ACID—GENERATION.

Supplies: NaCl, H_2SO_4, NH_4OH, lamp, flask, r.s., plate, asbestos, Wolff bottles, e.d.

1. (Rule 3.) Arrange a flask and 2 bottles with connections as in Fig. 32 (see also a Model). (Rule 6.) The rubber stopper in the bottle *A* has 3 tubes, only one of which (the safety tube) extends below the water. (Rule 4.) The second bottle has no stopper, and the tube just dips into the water. There are rubber connectors at *a* and *b*.

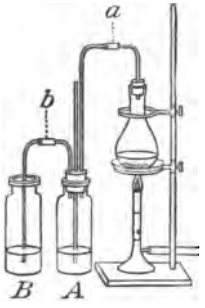


Fig. 32.

2. Fill the bottles not over one fourth full of water, into the flask put 10 or 15g of sodium chlorid NaCl (coarse salt, preferably fused), and cover it with about 20cc of sulfuric acid, H_2SO_4. (Rule 12.) If too little acid is used, the flask is liable to crack on heating.

3. Quickly adjust the apparatus, noting *very cautiously* any odor (if much gas is breathed, inhale ammonia NH_3 from a handkerchief), and heat slowly 10 or 15 minutes. Watch the bubbling or frothing in the flask, and state what it indicates to you. If it gets too vigorous, or extends near to the neck of the flask, take away the flame till it subsides. If the substance should run into the tubes, remove and clean the latter.

4. Look very closely at the liquid in the first bottle *A*, and see whether there is any movement. Describe and explain it fully. Does anything take place in *B*? Does the color of the substance in the flask change? If so, state how, and account for it.

5. Just before removing the lamp detach the app. at *a*, and hold close to *a* an e.d. containing a few drops of ammonium hydrate, NH_4OH. State the effect, the color, the name, and the cause, and write an equation. Try to ascertain whether the product is a solid or a gas. See what its effect is on combustion, using a burning and also a glowing splint. Remove the stopper from the flask, and thrust into the latter a burning splint.

6. Let the flask stand till it is cool enough to handle, then fill it with water, and, *without shaking it*, let it dissolve the solid or mix with the liquid. (Rule 11.) If the apparatus was loaned you, wash and return it, but save the liquids in *A* and *B* for Exp. 39.

39. HYDROCHLORIC ACID — PROPERTIES AND TESTS.

Supplies: HCl, solutions of $AgNO_3$, $Pb(NO_3)_2$, $HgNO_3$, $Cu(NO_3)_2$, Zn, $Zn(NO_3)_2$, litmus paper, splint, test tube, lamp.

1. Drop a piece of blue litmus paper into the liquid in *A*, Exp. 38; also one into *B*. State the effect and explain, showing just what it indicates.

2. Taste a drop of each from a s.r. What does the taste indicate?

3. Pour about 5^{cc} from *A* into a small t.t., and add 2 or 3 pieces of zinc. Describe the action, explain, and give the equation. Where have you seen similar action before? Take the odor of the gas, and try to ignite it with a burning splint. Describe, explain, and give reaction. Test the liquid in *B*, if you wish.

4. Pour into each of 5 test tubes about 5^{cc} of the liquid from *A*. Then pour into the first one a few drops of silver nitrate sol., $AgNO_3$; into the second a little lead nitrate sol., $Pb(NO_3)_2$; into the third mercurous nitrate sol., $HgNO_3$; into the fourth copper nitrate sol., $Cu(NO_3)_2$, and into the fifth zinc nitrate sol., $Zn(NO_3)_2$. Keep the results for comparison till the end of the exp.

5. In which cases did you get a precipitate, *i.e.*, a solid insoluble in the liquid? What was the color? Was there any other evidence of a chemical change? Can you think why a ppt. should form in some cases and not in others? Tabulate your results below:

REAGENTS.	PPTS. OR SOLS.	COLORS.	EQUATIONS.
$AgNO_3$.			
$Pb(NO_3)_2$.			
$HgNO_3$.			
$Cu(NO_3)_2$.			
$Zn(NO_3)_2$.			

6. Is there anything in this or the previous exp. which shows whether HCl is a gas or a liquid, and whether it is soluble in water? Enumerate the various properties of the acid which this exp. and the previous one teach you. (Rule 15.)

40. NITRIC ACID—PREPARATION.

Supplies: retort, r.s., plate, asbestos, test tube, tumbler, s.r., e.d., NH_4OH, $NaNO_3$, H_2SO_4.

1. Arrange a tubulated retort (of 250cc) on a r.s. (using plate and asbestos), as in Fig. 33. Have a ring above the retort to hold it in place. Have the end of the retort tube extend nearly or quite to the bottom of a large, clean and empty t.t. which reaches to the bottom of a tumbler filled with water. This can often be arranged by turning the upper ring, as well as the retort, a little to one side.

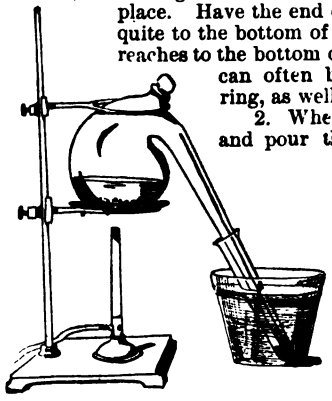


Fig. 33.

2. When it is adjusted, remove the retort, and pour through the tubulure from paper 8 or 10g of sodium nitrate, $NaNO_3$ (or KNO_3) and 10 or 20cc of sulfuric acid, H_2SO_4, holding the retort so as not to get any chemicals into its neck (Fig. 34). Note whether any action ensues, then replace the retort on the r.s.

3. Apply heat, and note carefully all phenomena, whether there are any fumes (if so, their color), whether the color changes with rise of temperature, whether there is effervescence, whether anything is visible in the retort tube, whether a liquid collects in the the t.t., and if so, its color. Explain fully all the phenomena, and write the main equation. Does the equation account for the fumes? Explain.

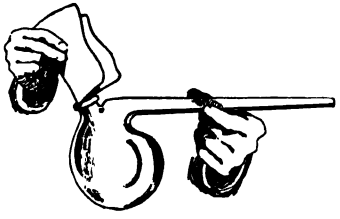


Fig. 34.

4. Apply heat for 10 or 15 minutes or until you collect 4 or 5cc of the liquid, then remove the lamp. Be very careful not to get any of the acid on the flesh. (Rule 7.) When it is cool enough to handle, take the stopper from the retort, and bring near the tubulure in an e.d. a few drops of NH_4OH. Describe, and explain the phenomena with equation. Remove the retort, and partly fill it with water cautiously, meanwhile not pointing the tube towards you. Then rest it in the tumbler (emptied of water). Finally, pour the contents through the tubulure into the sink, first opening the faucet to let the water run. If there is any solid undissolved, do not shake it, but let it dissolve. Save the liquid in the t.t. for Exp. 41, and return the app. loaned, first cleaning it. (Rules 17, 19.)

41. NITRIC ACID—TESTS AND PROPERTIES.

Supplies: HNO_3, NH_4OH, Cu, feather, written and printed paper, s.r.

1. (Caution, Exp. 40.) Note the color, and, cautiously, the odor of the liquid from Exp. 40, and test it with litmus paper.

2. Pour 2 or 3^{cc} of indigo sol. into a small t.t. and add a little of the acid, drop by drop, till a change is seen. Describe and explain.

3. With a s.r. put a drop on the finger nail, wash it off, note any effect, then put on a drop of ammonium hydrate, NH_4OH, and wash it off, noting the result.

4. Put a drop of the acid on a feather, or a piece of white silk, then wash, and treat it with NH_4OH as before. 3 and 4 show the action of HNO_3 on animal substances.

5. Put a few bits of Cu turnings into an e.d. and add a little of the liquid. Describe all you observe, with equations. Where have you previously seen similar phenomena? How does this show you have HNO_3?

6. Dip a splint into the acid. Compare its action with that of H_2SO_4.

7. Put a drop on writing paper, also on newspaper. This is a test for paper made from wood pulp.

42. ETCHING GLASS WITH HYDROFLUORIC ACID.

Supplies: glass plate, camel's-hair brush, lead tray, file, paraffin, HF, naphtha.

Caution. Be exceedingly careful not to get any of this acid on the flesh, as it is very corrosive. Avoid inhaling the fumes. HF is a gas, used like HCl, dissolved in H_2O.

1. For the use of a class, pour some hydrofluoric acid sol., HF, into a small leaden dish — it would dissolve a porcelain e.d. — and have a camel's-hair brush ready for use.

2. Let each pupil provide himself with a clean piece of transparent glass (*e.g.*, glass plate or t.t.), and with the brush spread a drop or two of the acid over a part of the glass, or mark a design on it. See whether you can detect any action. Leave it for 2 or 3 minutes, then wash off the acid and examine the plate. Describe fully.

3. Explain what has taken place and write the equation from the following data: Glass is composed in part of silicon dioxid, SiO_2; fluorin has great affinity for silicon, forming with it SiF_4.

4. If it is desired, a glass plate may be covered thinly on one side with paraffin or beeswax (melted in an e.d., spread on with a brush, and made even by warming the under side of the glass and pouring off the excess of wax), and a design (Fig. 35) marked through the wax with any pointed object, as a file handle. The acid is then spread several times over the lines of the design and finally washed off after some time. The wax can be melted and scraped off, and the glass washed with naphtha or alcohol.

Fig. 35.

5. Ascertain how hydrofluoric acid is made, and its use.

43. AQUA REGIA.

Supplies: HCl, HNO_3, Zn, Cu, Au leaf, test tubes, s.r.

PREPARATION.

1. Hold a small t.t. in the left hand nearly on a level with the eye, having the thumb nail at the point at which it is desired to have the liquid reach. Now pour into the tube about 5 or 6^{cc} of hydrochloric acid, HCl. Add to this not over 2^{cc} of nitric acid, HNO_3.

2. Watch the mixture a moment. If you see no action or change in color, hold it in a flame for a moment. Describe fully everything you observe — action, color, and, cautiously, odor. (Rule 17.) This is the odor of a mixture of Cl, NOCl (nitrosyl chlorid), etc. Write the equation.

TESTS AND PROPERTIES.

1. Put a piece of Zn into a t.t., and add a little of the aqua regia (also called nitro-hydrochloric acid). Describe the action, and explain it. Write an equation for Zn and Cl. See whether any combustible gas is liberated.

2. Put into an e.d. a few bits of Cu, and add a very little aqua regia. Describe and explain. Dip a splint into the sol. and hold it in a Bunsen flame. What colors do you distinguish?

3. Take up a piece of gold leaf, Au, on the end of a moist stirring rod, so that it will closely adhere to the rod. Dip the gilt end of the rod into a t.t. containing a little aqua regia, using care not to touch the sides of the tube. As the Au touches the liquid notice the action. Write the equation.

4. Using clean tubes and s.r. try, in the same way as above, whether Au will dissolve in either HCl or HNO_3. If not, pour the contents of the two tubes together.

5. After using *aqua regia*, fill the tube with water, open the faucet and then pour out the liquid. (Rule 11.)

44. SULFURIC ACID — PREPARATION.

Supplies: S, HNO_3, lamp, combustion cup, wide-mouth bottle, glass plate, test tube, e.d.

1. (Rule 16.) Burn in a rec. covered with glass a piece of sulfur about half the size of a pea, using a combustion cup, and setting fire to the S in the usual way (Exp. 15). Note the color of the flame and of the fumes, also, cautiously, the odor of the latter. Write the equation. When combustion nearly stops, remove the S, extinguish the flame with a drop of water, and keep the rec. covered with paper or glass.

2. Pour into an e.d. 2 or 3^{cc} of nitric acid, HNO_3. Dip into this one end of a piece of paper folded several times, and hang it in the rec. so as nearly to reach the bottom but not to touch it. Note any change in the color of the fumes, and explain, writing equations also. Watch carefully for other phenomena, and describe. (Rule 20.)

3. Boil in a t.t. 5 or 10^{cc} of H_2O and pour it into the rec. of SO_2.

4. After about 5 minutes remove the paper (use care not to get any acid on the bench or clothing). Now cover the mouth of the rec. with the hand or a stopper, and shake the contents thoroughly together. Write equations to represent the action supposed to take place, and explain the action.

5. Save the liquid in the rec. for Exp. 45. Carefully rinse the remaining acid from the e.d. into the sink. Ascertain how H_2SO_4 is made on the large scale.

45. SULFURIC ACID — PROPERTIES AND TESTS.

Supplies: H_2SO_4, NH_4OH, $BaCl_2$ sol., HCl, Zn, starch, sugar, e.d., test tubes, litmus paper, s.r., writing paper.

1. Put into a large t.t. about 5^{cc} of H_2O, and slowly add as much commercial sulfuric acid, H_2SO_4. Note the thermal (*i.e.*, heat) effect (stir the mixture if desired with a very small t.t. containing 2 or 3^{cc} of ammonium hydroxid, NH_4OH, or test it with a thermometer). If commercial acid is used, see whether any ppt. forms. It is probably $PbSO_4$. Explain (study the manufacture of sulfuric acid). Cool the mixture by holding the t.t. under a jet of water. Apply the following tests, side by side, to this acid and that from Exp. 44 :

2. Test each with litmus paper, and state what the test shows.

3. Test for SO_4 by pouring into a t.t. 4 or 5^{cc} of barium chlorid sol., $BaCl_2$, and add 1 or 2^{cc} of the acid. Describe and explain. Now add 1 or 2^{cc} of HCl, and shake well together, noting whether the ppt. dissolves. Barium sulfate, $BaSO_4$, is the only salt of Ba which is not dissolved by HCl. How does this show that the acid you have is H_2SO_4 ?

4. Put a drop of each acid, with a s.r., on a piece of writing paper, place this on a tin plate 6 or 8 inches above a small flame, so as not to burn the paper but to evaporate the acid. Note the effect on the fibre and color of the paper.

5. Dip a splint into the acid, and leave a minute. Examine and explain, remembering that both wood and paper consist largely of cellulose, $C_{18}(H_2O)_{15}$.

6. Put about a gram of sugar, $C_{12}(H_2O)_{11}$, into a dry e.d. and add a drop or two of the acid. Account for the effect.

7. Put into a t.t. a small fragment of starch, $C_6(H_2O)_5$, and add a few drops of acid. If no change takes place, heat it a moment. State the result, and explain it.

8. Try the action of the acids on zinc in a t.t., applying usual tests. (Rule 19.)

46. AMMONIUM HYDROXID — PREPARATION.

Supplies: Wolff bottles, flask, plate, asbestos, delivery tubes and connectors, r.s., lamp, NH_4Cl, $Ca(OH)_2$, HCl.

1. (Rule 14). Connect a flask with Wolff bottles, as in Fig. 36, the same as for making HCl. In the first bottle, *A*, only the safety tube should dip into the water. The bottle *B* should be left open. Have an upper ring, to hold the flask in place, and a lower one on which is placed a tin plate, asbestos, and the flask. This ring should be 5 or 10^{cm} above the top of a Bunsen burner. Have rubber connectors at *a* and *b*.

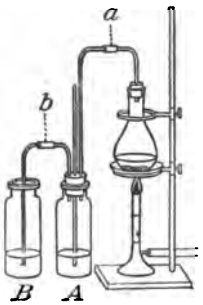


Fig. 36.

2. Pour water into *A* to a depth of about 4 or 5^{cm}, and into *B* till it covers the end of the tube.

3. Mix on paper about 10^g of ammonium chlorid, NH_4Cl, and 10^g of recently slaked lime (calcium hydrate), $Ca(OH)_2$. Pour it into the flask (of 250^{cc}), and add 10 or 15^{cc} of water. Note any odor, or other phenomena.

4. Adjust the apparatus, and apply heat 10 or 15 minutes. Note any action in the flask, the connecting tubes, or the bottles, and explain. See whether any odorous gas rises from *B*, or whether the liquid colors litmus paper (red or blue).

5. Pass some of the gas over a few drops of HCl in an e.d., at *a*. Describe and explain. Where have you previously made a similar test?

6. Let the flask stand till cool enough to handle, then fill with water and clean it (with a few drops of HCl, if necessary). Return any borrowed apparatus. (Rule 4.) Save the liquid, especially in the first bottle, for Exp. 47.

47. AMMONIUM HYDROXID AND AMMONIA.

Supplies: solutions of $FeSO_4$, $FeCl_3$, $AlCl_3$, $CuCl_2$. Also NH_4OH, $Ca(OH)_2$, $(NH_4)_2C_2O_4$, NaOH sol., etc., test tubes, cleaners, etc.

1. (Rules 10, 9, 8.) Pour into a clean t.t. about 5^{cc} of ferrous sulfate sol., $FeSO_4$, and add 5^{cc} of the NH_4OH made in *A*, Exp. 46. Note the effect, giving color, state, and name of the observed product. State what the exp. shows, and write the equation.

2. Test the same quantity of ferric chlorid sol., $FeCl_3$, in the same way, stating with care all the results and what they show, also writing the equation.

3. Try the effect on 5^{cc} of a sol. of aluminum chlorid, $AlCl_3$, and take full notes.

4. Try the action on 5^{cc} of copper chlorid sol., $CuCl_2$. Add first a very little NH_4OH, and note all color effects. What parts are clear? Where is there a ppt., and what is its color? Shake it and add more NH_4OH. See whether it finally becomes clear. Explain all the phenomena.

5. Mix on paper 2 or 3^g of some salt of ammonium, as $(NH_4)_2C_2O_4$, with the same quantity of slaked lime, $Ca(OH)_2$. See whether there is any odor. Put the mixture into a test tube and warm it, meanwhile noting any odor, and testing with litmus paper and HCl.

6. Put into a test tube 2 or 3^g of an ammonium salt, and add a little sodium hydrate, NaOH, or potassium hydrate, KOH, sol. Warm the mixture, applying tests as before.

7. Write in a vertical column symbols of half a dozen ammonium salts, and in a parallel column symbols of three bases which might be used with them to form ammonia. Write several equations to indicate the preparation of ammonia. (Rule 15.)

8. Berthollet's Law of Gases. *If a gas can form by the reaction of two or more substances, it will always be liberated on mixing those substances.* Apply the law in 7.

48. SODIUM AND POTASSIUM WITH WATER.

Supplies: Na, K, sols. of $FeCl_3$, $AlCl_3$, and $CuCl_2$, forceps, e.d., knife, lamp, rec., litmus paper.

1. Put into a small rec. 10 or 15^{cc} of H_2O, and have ready a piece of paper to cover the rec.

2. With the forceps take a small piece of metallic sodium not larger than a pea from the naphtha in which it is kept and place it in a dry e.d. Cut off a bit from the side and notice its color and luster when freshly cut, also how easily it oxidizes, and what change it then undergoes.

Fig. 37.

3. Drop the Na into the rec., cover the latter at once with paper, and watch the result. (Fig. 37.) Describe the action, note the effect on the Na, the water, and the air over the water, and explain it. Note which has the higher sp. gr., the metal or the water. Write the equation.

4. *As soon as the action stops* remove the paper and try to ignite the gas. If it burns, explain, with reaction.

5. Heat to boiling in a t.t. about 10^{cc} of H_2O, pour it into a clean empty rec. (previously having a piece of Na ready in an e.d.), drop the Na into the hot H_2O, cover it quickly, and watch the effect. If there is no flame, heat the water again and try it once more. Note any new phenomena, color of flame, etc., and explain. If a cloud appears, see whether it is solid or gaseous. Four equations should be written for — (1) the action of Na on hot H_2O, (2) the action of Na on O, (3) the action of H on O, (4) the action of Na_2O on H_2O.

6. Hold the basal opening of a Bunsen burner close to the mouth of the rec. (Fig. 37), *immediately after the Na has ceased to act on the water.* This will show the characteristic sodium flame. Note its color.

7. Test the liquid, adding a little to 5^{cc} of a sol. of each of these: $FeCl_3$, $AlCl_3$, $CuCl_2$. If no ppt. falls the NaOH is too weak. In that case put in another piece of Na. Results and equations. Try the litmus test.

8. Try the action of K on *cold* water, not on hot, in the same way as with Na, noting all effects, especially the color imparted to a Bunsen flame.

49. SODIUM AND POTASSIUM HYDROXIDS.

Supplies: solutions of Na_2CO_3, $Ca(OH)_2$, $FeCl_3$, $AlCl_3$, $CuCl_2$, K_2CO_3, lamp, r.s., test tube.

1. Pour into a large t.t. 5 or 10^{cc} of a weak solution of sodium carbonate, Na_2CO_3, and add an equal volume of calcium hydroxid sol., $Ca(OH)_2$. Note whether a ppt. falls, and whether the action is slow or rapid. Boil the contents, and set aside for a few minutes.

2. Write the equation and ascertain (from Table A) which of the products is insoluble and hence precipitated.

3. Separate the two products by filtration. Which remains in the filtrate?

4. Evaporate the water from the filtrate in an e.d., leaving the substance as a solid. Rub a little between the fingers and note the effect. Explain.

5. Add 5 or 10^{cc} of H_2O and stir the residue. Is the latter soluble? Test it with both colors of litmus paper.

6. Add a little to 5^{cc} of a sol. of each of the following, and note all the results, giving equations: $FeCl_3$, $AlCl_3$, $CuCl_2$.

7. Make potassium hydroxid, KOH, in the same way from sols. of potassium carbonate, K_2CO_3, and lime water, $Ca(OH)_2$. Make all the tests and state the results, as in the case of NaOH.

50. NITROGEN MONOXID—PREPARATION.

Supplies: apparatus in Fig. 38, NH_4NO_3.

1. Arrange the apparatus as in Fig. 38. Connect a flask *A* (of 200^{cc} capacity) with an empty bottle *B*, and from the latter lead a delivery tube to a pneumatic trough on the shelf of which are two or more inverted receivers filled with water. Have the bearings all tight.

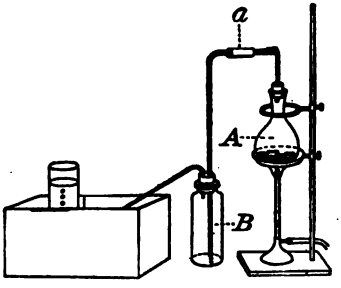


Fig. 38.

2. Put into the flask 10 or 15^g of ammonium nitrate, NH_4NO_3. Apply heat and reject the first part of the gas (which is air driven over from *A* and *B*). Obtain 2 or 3 receivers of the gas. If the action is too strong, take away the lamp for a minute. Don't let the water draw back from the trough into *B*, but watch it closely, and check any tendency to do so by disconnecting at *a* as soon as the lamp is removed.

3. Record the phenomena in the order of its occurrence. What action was first seen in *A*? Is there evidence of a gas or a solid, or both, in the fumes which rise? What is the evidence? What is the gas or the solid likely to be? What is seen in *B*? In the receivers? Give the equation for the decomposition or dissociation of the nitrate.

4. While gas is still escaping disconnect the apparatus at *a* and test the reaction of the gas with litmus. Observe any action on the cork of the flask. Rinse out the tubes after finishing the exp., save the receivers of gas and the contents of *B* for Exp. 51. If the receivers are removed from the water, keep them upright, covered with glass. N_2O is also called nitrous oxid. (Rule 17.) Fill *A* with water.

51. NITROGEN MONOXID — PROPERTIES.

Supplies: N_2O, $Ca(OH)_2$ sol., S, P, litmus paper, e.d., s.r., splint, lamp.

1. Test the combustibility or supportability of the gas (Exp. 50) in one of the recs. by thrusting a burning splint into it, then a glowing one. Compare its action and vigor with the same in oxygen, air, hydrogen, nitrogen. What becomes of the nitrogen in N_2O of this exp., and what compound is formed? Test this compound by pouring about 10^{cc} of lime water, $Ca(OH)_2$ sol., into the rec. (after burning the splint), shaking the liquid and gas thoroughly together, then pouring into a t.t. Give an equation.

2. Try the combustibility of S or P, or both, in N_2O (ignite the S by directing a flame upon it in a combustion cup till it burns vigorously). Compare the combustion with that in air. Cautiously take the odor of the product. What is the product? Write the equation.

3. Taste a drop of the liquid in the bottle *B*, using a s.r. or the finger. Taste also some of the original salt, NH_4NO_3, and compare them. Test the liquid with litmus paper. If the reaction is acid, pour some of the liquid into an e.d., and add a very small pinch of copper turnings. Boil till it has nearly all evaporated. State your observations and conclusions.

4. How could you distinguish N_2O from H? From N? From O? From SO_2?

52. NITROGEN DIOXID — PREPARATION.

Supplies: Cu, HNO_3, apparatus as in Fig. 39, pneumatic trough, etc.

1. Arrange a gas gen., as in Fig. 39, and connect with a pneumatic trough with 3 inverted recs.

2. Put into the gen. — using paper for this purpose — 8 or 10g of fine copper turnings, and cover them with water, avoiding excess. Pour through the thistle tube — which should extend below the water — a little nitric acid, HNO_3. Reject a little of the gas at first, as it is mostly air. *Add acid enough to obtain strong action.*

Fig. 39.

3. Describe the action, and see whether you can ascertain its origin. Note any color changes in the liquid and in the gen. over the liquid, also in the recs. as the gas collects, and account for all of them, writing the corresponding equations. Note whether the temperature of the gen. changes, and explain.

4. Avoid filling the room with fumes, but after collecting what gas you wish, stop the action by filling the gen. with water, and — *after opening the water jet* — pour the liquid slowly out, leaving the copper in the gen., not getting any into the sinks. Rinse the copper with water once or twice, and then return it to a receptacle.

5. Leave the recs. in the trough till you are ready for Exp. 53, or remove them with glass plates, placing them upright, covered with the plates. This gas, NO, is also called nitric oxid.

53. NITROGEN DIOXID—PROPERTIES.

Supplies: NO, S, P, litmus sol., splint.

1. Remove the cover from a rec. of nitric oxid, NO (Exp. 52), describe the result, and explain it, with equation. *Cautiously* take the odor. Cover the rec. again before all the gas escapes, and add 10^{cc} of litmus sol., shaking it well with the gas. Describe, and explain.

2. See whether NO will support the combustion of carbon, using a splint. A small bit of sulfur in a combustion cup may also be tried—ignite the S with a Bunsen flame, and test the gas in the same rec. in which you tested it with carbon.

3. Try the combustibility of phosphorus with the third rec., *using a piece as large as a pea*, igniting it with a hot wire, and having it burn *vigorously* before lowering it into the rec. State all observations, name products, and give equations. How many sorts of fumes do you see? Cover the rec. and let it stand, noticing whether the different fumes tend to separate. Explain fully. Is NO a supporter of any kind of combustion? Does it readily oxidize? Is it a combustible? Give reasons for each answer. State how you could recognize the gas NO. How could you distinguish it from oxygen, hydrogen, nitrogen, NH_3, HCl?

54. NITROGEN TETROXID AND TRIOXID.

Supplies: NO, $Pb(NO_3)_2$, starch, HNO_3, lamp, test tube and holder, splint.

1. State how nitrogen tetroxid, NO_2, was made from nitric oxid, NO (Exp. 53), with evidence of the change, and the equation.

2. Put into a very small and dry t.t. 3 or 4 crystals of lead nitrate, $Pb(NO_3)_2$. Hold the tube in the flame with the left hand, using a tube holder, and thrust a burning or glowing splint into the tube while the action is going on. (Fig. 40.)

3. Describe all evidences of chemical action in the order of occurrence. What was the result of the splint test, and what did it show? Notice the color of the residue in the tube. The nitrate broke up into three products, two of which were lead oxid, PbO, and NO_2. Write the equation, and state what the third one was, and what evidence you had of its presence.

Fig. 40.

4. The residue, PbO, may be removed from the t.t. by adding a little nitric acid and letting it stand.

5. Put into a t.t. a small piece of starch, $C_6H_{10}O_5$, add 3 or 4 drops of nitric acid, and heat cautiously for a moment, using a tube holder. Test the gas with a splint. Is it a supporter, or a combustible, or neither, or both? State the action of the starch and acid in forming the gas, but the equation need not be attempted. NO_2 (N_2O_4 when liquid) is often called nitrogen peroxid, and N_2O_3 nitrous anhydrid. At a low temperature the latter can be reduced to a blue liquid, but at the ordinary temperatures both N_2O_3 and NO_2 are red-brown gases. In what exps. have you seen them before? Note that the various oxids of nitrogen are made by the breaking up of some nitrate.

55. CARBON DIOXID.

Supplies: apparatus as in Fig. 41, recs., test tubes, litmus sol., lime water, HCl, splint, glass tube, e.d.

1. Arrange a gas gen. as in Fig. 41, have 2 open recs. and 3 test tubes, one of which contains about 5^{cc} of blue litmus sol., and each of the others 5 or 10^{cc} of clear lime water, $Ca(OH)_2$, sol.

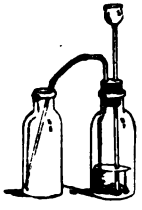


Fig. 41.

2. Put into the gen. 20 or 25^g marble chips, $CaCO_3$, cover them well with water and add through the thistle tube a little hydrochloric acid, HCl.

3. Watch the action, and see whether you can determine its origin. Describe, and see whether any colored gas is formed. Collect 2 recs. of gas by downward displacement. Add acid enough for strong action. Write the equation.

4. Test the gas in one rec. with a burning splint, also a glowing one. State result and conclusion. An interesting exp. consists in noticing the gradual filling of a rec. with CO_2. To do this thrust a lighted splint repeatedly into the rec., as soon as the gas begins to collect. Note how far the splint can be thrust each time into the rec. and still burn.

5. Pass some of the gas into the litmus sol. (having the d.t. reach well into the liquid), observe the effect and explain it.

6. Pass the gas into one of the tubes containing lime water. If a ppt. falls, note its color, state why it is formed, and give the equation. This is the test for CO_2. Let the gas bubble through it (add HCl to the gen. if necessary) till it clears. Explain fully why it clears, giving the equations. Now boil it a minute or two (see whether it boils more or less easily than water, and explain), and state fully the reason for the result you get, with equations. Now add a few drops HCl. Dip a splint into the liquid of the gen. and hold it in a Bunsen flame, noting the color, due to Ca compounds in solution.

7. Blow into the lime water in the other tube, using a glass tube, which should extend nearly to the bottom of the liquid. State the result and what it shows.

8. Expose to the air of the room a little $Ca(OH)_2$ sol. in an e.d. After some minutes look for any deposit on the top or bottom, and explain.

36. STRUCTURE OF FLAME.

Supply: Bunsen lamp, [illegible] burner, [illegible] lamp, candle.

1. Examine the structure of a typical Bunsen flame — [illegible] the outline of the inner part [illegible] easily seen. Which is the hottest part? [illegible] a card held to cut off the flame more clearly [illegible] it is most sensitive to pressure and set it [illegible] on a white background.

2. Make a drawing of a vertical section of the flame and of a transverse section, labelling each part.

3. Observe the orifices at the base of the burner and close them for a moment with the fingers, noting any changes in the flame and light. See whether you can detect an inward suction or an outward pressure at the open tube. Try to ascertain what these openings are for.

4. Make a drawing to show these basal openings and their relation to those for the entrance of the gas into the burner with the tube removed. Light the gas from this latter tube for a moment, and observe the flame.

5. Study and make a drawing of the ordinary gas flame (luminous flame) marking the parts. Now turn it very low, and observe.

6. Do the same with a candle or lamp flame.

7. State any similarities in the flames examined. State the chief difference between the Bunsen and candle flames. Hereafter examine carefully every flame you see and ascertain whether the general structure is alike in all cases.

56. STRUCTURE OF FLAME.

Supplies: Bunsen lamp, fish-tail burner, kerosene lamp, candle.

1. Examine the structure of a typical Bunsen flame — in which the outlines of the inner part can be clearly seen. What is its shape and the shape of each part? Hold it in front of a dark object, to bring out the parts more clearly. Also place it in direct sunlight, if possible, and let its shadow fall on a white background.

2. Make a drawing of a vertical section of the flame, also of a transverse section, labeling each part.

3. Observe the orifices at the base of the burner and close them for a moment with the fingers, noting any changes in the flame and light. See whether you can detect an inward suction or an outward pressure at the openings. Try to ascertain what these openings are for.

4. Make a drawing to show these basal openings and their relation to those for the entrance of the gas into the tube, using a burner with the tube removed. Light the gas from this latter tube for a moment, and observe the flame.

5. Study and make a drawing of the ordinary gas flame — fish-tail flame — marking the parts. Now turn it very low, and observe.

6. Do the same with a candle or lamp flame.

7. State any similarities in the flames examined. State the chief difference between the Bunsen and candle flames. Hereafter examine carefully every flame you see and ascertain whether the general structure is alike in all cases.

57. COMBUSTION AND HEAT OF FLAME.

Supplies: Bunsen lamp, splints, paper, platinum wire, match, glass tube.

1. Light the gas of a Bunsen burner. Put a splint across the flame, about 1^{cm} above the top of the lamp, for a moment, remove, blow out the flame, and note what parts are charred. Make a sketch, and state what the exp. shows.

2. Hold a splint across the flame just above the inner cone. Notice the different effect from that of the previous exp. and state what it shows, with a drawing to indicate the burned part.

3. Press down in the flame with a stiff paper (*e.g.*, writing paper) or cardboard below the top of the inner cone, remove the paper quickly before it burns, and blow out the flame if there is any. Notice the shape of the charred part, and make a sketch. In what part of the flame does this exp. show there is no combustion? In what part does it seem to be most complete?

4. Test the heat of the *inner cone* with the end of a Pt. wire, noting the glow. Move the wire from the bottom to the top of the flame, and state what the exp. indicates as to temperature.

5. Thrust the phosphorous end of a match quickly into the lower part of the inner cone, and see whether the P burns at once. Explain.

6. Put one end of a small d.t. into the inner cone (not into the lamp tube but about 1 or 2^{cm} above it), and try to light the gas at the other end. It is better that the d.t. taper at the outer end, and that two persons make this exp. together. Now gradually raise the d.t. from the inner to the middle cone, and note the effect.

7. From the above exps. state what takes place in each of the two cones, and the cause of the difference, if possible.

58. LIGHT OF FLAME.

Supplies: Bunsen flame, charcoal, glass tube or crayon.

1. Observe and describe the light and colors of the different parts of a Bunsen flame.

2. Make a drawing to show them, marking the different parts.

3. Sprinkle a trace of charcoal dust from a piece of paper into a Bunsen flame, and note the effect as regards light and color. Strike the lamp tube lightly with the fingers. Also stir up a little dust from the table, and notice the effect on the flame.

4. Close the orifices at the base of the burner either with the fingers or by turning the sheath. State and explain the change, comparing the light, color, steadiness, length of flame, and completeness of combustion with those of the Bunsen flame. Successively open and close the orifices for this purpose. Make very careful comparisons in order to ascertain the cause of the differences. Does the cause seem in any way to resemble the production of light in 3?

5. Hold for a minute a short glass tube or a crayon in the upper part of the flame, having the orifices closed, and look for any sublimate. Describe it. Now open the orifices and try to burn off the deposit, holding the tube in the part just above the inner cone. What does this exp. show of the heat and the combustion of the two flames?

6. In what way do the above exps. show the cause of light in a flame? What is that cause in most flames?

59. KINDLING POINT OF FLAME.

Supplies: lamp, wire gauze.

1. Light the gas of a Bunsen burner, and with a fine wire gauze (10×10^{cm}), held with forceps, press down on the flame to 4 or 5^{cm} above the burner. Try this several times, and state the result. Can you see any cause for the effect? Is there any different effect after holding it there for some time?

2. Turn off the gas, then turn it on, and before lighting it hold the gauze 4 or 5^{cm} above the burner, then relight it above the gauze. See what takes place beneath the gauze, and explain. Try this several times, and gradually lift the gauze higher and higher. State what finally takes place, and why.

3. Again light the gas above the gauze, holding the latter as before, and in the left hand, then with another gauze in the right hand press down above the flame. State what happens above the upper gauze, below the lower, and between the two, and give a full explanation.

4. Gradually and slowly turn off from a Bunsen burner the lighted gas till you hear a slight explosion, and it stops burning at the top, then turn it on again. See whether it "burns at the base." Try to light it at the top, and see if the flame looks as before. Try this till you succeed in making it burn at the base. This illustrates an explosive mixture of the combustible and the supporter.

5. The kindling point of a substance is the temperature at which it will take fire and below which it will not take fire. See whether any of the above exps. illustrate this principle. Ascertain some substances which burn at a low temperature. Some which burn at a high temperature.

60. OXIDIZING AND REDUCING FLAMES.

Supplies: forceps, lamp, blow pipe and attachment, PbO, charcoal, lead.

1. With the rounded end of the forceps bore a slight depression in a piece of charcoal, and put in a piece of lead wire ($\frac{1}{2}^{cm}$ long) or other fragment of lead.

2. Put a blow-pipe attachment on a Bunsen burner, light the gas and turn it down to a convenient-sized flame (3 or 4^{cm} high). Blow the flame with a mouth blow-pipe, resting the tip on the lip of the attachment. Notice, as you blow, the parts of the flame. The outer is called the oxidizing flame (o.f.). Why? The inner is the reducing flame (r.f.). Why? Blow steadily and continuously, breathing meantime.

3. Now take the charcoal in the left hand, and blow the o.f. directly against the lead (Fig. 42). Blow continuously for some minutes, and observe what takes place. Notice any vapor that arises from the lead, and give its color. Also see whether any coating is formed on the coal, and give its color. A portion of the outer part of the lead has been changed to PbO. Write the equation, and explain more fully.

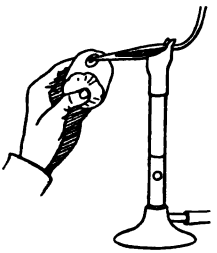


Fig. 42.

4. Take the lead from the coal, and put into the depression (which may be renewed if necessary) about $\frac{1}{2}^{g}$ of lead monoxid, PbO. Carefully blow the r.f. (inner) steadily against it for some time. This must be done in such a way as not to blow away the PbO. Describe the phenomena. What product is finally obtained? Remove it with the forceps, try to cut it and crush it. Write an equation to show what the reducing flame has done to the PbO, and explain fully.

5. If the coal still glows after some time, put on a drop of water.

61. COMBUSTION UNDER WATER.

Supplies: test tube, thistle tube, phosphorus, $KClO_3$, H_2SO_4.

1. Put into a wide t.t. 1 or 2^g of potassium chlorate crystals, $KClO_3$, add water to the depth of 3 or 4^{cm}, and drop into the tube a bit of phosphorus not over half the size of a pea.

2. Cover the t.t. with paper, and pour through a thistle tube, which passes through the paper (Fig. 43), *a few drops* of sulfuric acid, H_2SO_4. If the action is not vigorous enough, pour in more acid (*avoid excess*), then remove the thistle tube, and watch the phenomena.

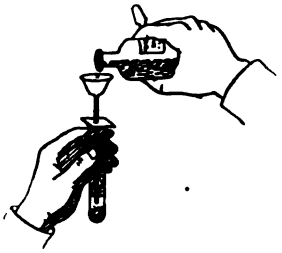


Fig. 43.

3. Record any sound or light, and any color changes in the liquid or above it, any odor, effervescent action or liberation of gas, change in the temperature of the tube, etc. $HKSO_4$ and $KClO_4$ (name them) are formed by action of the acid on $KClO_3$, and ClO_2 is liberated. The latter oxidizes the P and sets Cl free. What evidence have you of the existence of any one of these products? Write the equation, if you can. State what in this experiment illustrates each of the conditions of combustion.

Caution.—These substances must never be mixed together, except under water, and even then only in small quantities.

62. CHLORIN — PREPARATION.

Supplies: apparatus as in Fig. 44, MnO_2, HCl.

Caution.—Avoid inhaling Cl, it is very stifling and injurious. Alcohol or ammonia (inhaled from a handkerchief) is the antidote. Exps. of this kind may, at his discretion, be done by the teacher for the class, the latter making full notes.

1. Arrange an apparatus as in Fig. 44. With a flask (of 200 or 250^{cc} capacity) connect a small dryer (8 or 10^{cm} long) filled with calcium chlorid, and lead a tube from this to the bottom of an open empty rec.

2. In the flask place 10 or 12^{g} of manganese dioxid, MnO_2, and pour 25 or 30^{cc} of muriatic acid, HCl, through the thistle tube (the end of which it must cover). Shake the acid and MnO_2 well together, and notice any color or other effect.

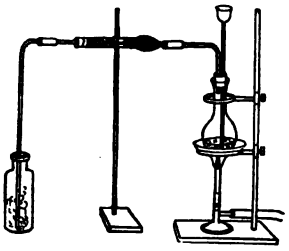


Fig. 44.

3. Apply gentle heat to the flask, using plate and asbestos, and look for any coloration in the gas as it collects in the bottom of the rec. Before the latter is quite filled remove it, and put another one in its place. Fill 2 or 3 recs., adding more acid, and shaking the mixture if necessary. If the gas which escapes begins to grow white, more acid is needed, and it may be better to pour out the liquid, and begin again. Cover the recs. with glass as fast as the Cl is prepared, and proceed at once—before writing your notes—to do Exp. 63.

4. In taking notes, state the color and the relative specific gravity of the gas, and write the equation. Note the change of valence in Mn in the factor MnO_2, and in the product $MnCl_2$. Describe the odor from what gas gets into the air, but do not inhale the pure gas.

5. Run water into the flask (opening the faucet before pouring the liquid contents into the sink). Some of this liquid may be filtered if desired, and the color noted. What compound does it contain? Compare its color with that of the same compound in solid form.

63. SOME PROPERTIES OF CHLORIN.

Supplies: chlorin, antimony, calico, green leaf, spirits of turpentine, lamp.

1. Drop into one of the recs. of Cl (Exp. 62) 1 or 2 small dry pieces of calico, cambric or Turkey red cloth, a flower petal, leaf, etc. Leave them for a few minutes (doing 2 meanwhile). If the color is not taken out add 2 or 3^{cc} of water, shake it up well, and let it stand for some time. Note whether dry or wet material bleaches better.

2. Take a piece of a crystal of antimony, and file small particles of it into one of the recs. of Cl, taking off the cover for that purpose. Look carefully for any phenomenon, and any product. What colors were noted in each, and was the product apparently a solid or a gas? As the factors consisted of two elements, antimony and chlorin, what was the product likely to be? Write the equation, noting the valence of each element.

3. Dip a strip of paper into a little spirits of turpentine in an e.d., warm it for a moment by holding it near the flame (but not near enough to set it on fire), then quickly thrust it into a rec. of Cl, moving it rapidly up and down. If the Cl is strong and dry, a quick flame is seen, due to the strong affinity of hydrogen and chlorin. Turpentine is $C_{10}H_{16}$. Write the equation. What evidence is there that only the H combined with the Cl? State all the phenomena. Of what sorts of combustion is Cl a supporter?

4. How would you distinguish Cl from HCl? From NO? From CO_2?

64. EUCHLORIN (CHLORIN WATER).

Supplies: calico, $KClO_3$, HCl, sols. of indigo, cochineal, litmus, and $K_2Cr_2O_7$.

1. Put into a clean t.t. 4 or 5 crystals of potassium chlorate, $KClO_3$, and add a few drops of muriatic acid, HCl. If any action ensues, describe it, and give color, state, etc., of the products.

2. Heat the tube a moment (describe further effects), and at once half fill the tube with H_2O. Balance the equation:

$$KClO_3 + HCl = KCl + H_2O + ClO_2 + Cl.$$

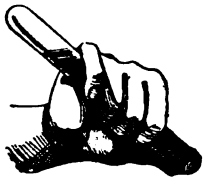


Fig. 45.

Avoid inhaling the gas, but describe the odor from what gets into the air. Save the euchlorin, and test its properties as follows:

3. To 4 or 5^{cc} of indigo sol. in a small t.t. add a very little euchlorin, drop by drop, noting any change, and when that takes place at the top, invert the tube (Fig. 45). Describe and explain.

4. Try the action of the $Cl + ClO_2$ sol. on 4 or 5^{cc} of cochineal sol., and state whether it is bleached.

5. Test litmus sol. in a similar way, and give results.

6. Try a sol. of potassium dichromate, $K_2Cr_2O_7$, and state whether the result is as you expected.

7. Try to bleach a piece of calico or Turkey red cloth by leaving it immersed in a t.t. of euchlorin.

8. Add a little euchlorin to hydrogen sulfid sol., H_2S (Exp. 70). Describe, explain, and give an equation.

65. BROMIN.

Supplies: KBr, MnO_2, H_2SO_4, sols. of indigo, litmus, and starch, test tubes, evaporating dish, r.s., lamp, etc.

Starch sol.—Put into an e.d. not over half a gram of pulverized starch, wet it with a few drops of water, boil in a t.t. about 10^{cc} of H_2O, and pour it over the starch, stirring it well. Add 10^{cc} more of water, stir and boil it for 2 or 3 minutes in the e.d., using plate and asbestos. Then pour it into a beaker or t.t., and save it for the Br and I exps. Use only a small quantity for each exp.

1. Mix on paper 3 or 4 crystals of potassium bromid, KBr, with about the same quantity of manganese dioxid, MnO_2, put the mixture into a t.t., and add 1 or 2^{cc} of H_2SO_4. Observe the effect, holding the tube to the light.

2. Heat it for a moment (Fig. 46), but do not drive the gas into the room. Look for any liquid particles on the sides of the tube. What are they likely to be? Before the tube gets full, pour off the gas into one or more recs., then cover the latter with glass or paper.

3. Note the color of the gas (see whether any liquefies), and the weight as compared with air. Do not inhale the fumes (ammonia or alcohol is an antidote), but note any effect of the atmosphere of the room on the eyes.

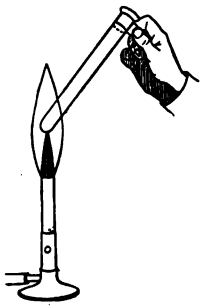


Fig. 46.

4. Pour into the rec. of bromin vapor 4 or 5^{cc} of indigo or litmus sol., and shake the contents thoroughly. Observe and explain.

5. Pour a little of the gas from the Br gen. into a t.t. containing a very little starch sol. (prepared as above), shake the contents, note the color effects, and state a test for bromin. Bromid of starch is formed.

6. Write an equation for the preparation of bromin, and compare it with that for chlorin.

7. The t.t. may be cleaned with a little muriatic acid and heat.

66. IODIN.

Supplies: MnO_2, KI, H_2SO_4, iodin, starch sol., lamp, s.r., test tubes.

1. Generate iodin in this exp. like Br in the previous one, mixing 3 or 4 crystals of potassium iodid, KI, with the same bulk of manganese dioxid, MnO_2, putting them into a tube and adding 1 or 2^{cc} of H_2SO_4.

2. Heat gently, observe and explain all the phenomena, and write an equation for the reaction.

3. Put into a small and perfectly dry t.t. 2 or 3 crystals of iodin. Describe their color, luster, and form. Warm the closed end of the tube for a moment, then note the color and state of the product. Thrust a dry s.r. into the fumes in the t.t., and carefully examine it after a minute. Watch the tube till the color fades out, and try to ascertain what has become of the gas. Look down into the open end of the tube in direct sunlight if possible. Describe fully.

4. Heat and vaporize the iodin again, and pour some of the vapor into a little starch sol. (Exp. 65) in a t.t. Save the rest for Exp. 67. Shake the starch and I sol., and note the color. Iodid of starch is the product. If the liquid is thick, dilute it with water and shake it.

67. IODIN.

Supplies: iodin, alcohol, sols. of KI and starch, $KClO_3$, HCl, test tubes.

1. Pour 4 or 5^{cc} of alcohol, C_2H_5OH, into the t.t. containing the sublimed iodin (Exp. 66), and shake the contents very vigorously. Warm the tube if necessary. State the effect on the alcohol and on the iodin. What does this exp. show you about the solubility of iodin? The product is called tincture of iodin.

2. Prepare 5 or 10^{cc} of euchlorin (Exp. 64) in a t.t. for use in the following.

3. Pour into a clean t.t. 3 or 4 drops of potassium iodid sol., KI, and 2 or 3 drops of starch sol. (Exp. 65). Add 5^{cc} of H_2O, and shake the contents. Now dip a s.r. into the euchlorin, and in this way stir a drop of the euchlorin into the starch and KI sol. If there is no visible effect, repeat the last operation with another drop of euchlorin. Describe in full, and explain with an equation to show the relative affinities of I and Cl for K. Boil the sol., and note the effect, then cool it with a jet of water. Explain.

4. Show how the above becomes a test for iodids. Apply the test in several cases if you have time, asking the teacher for solutions.

68. SULFUR.

Supplies: beaker, test tubes, e.d., lamp, etc., sulfur, CS_2.

I. CRYSTALLIZATION.

Into a small beaker or large t.t. put 10 or 15^g S, and slowly melt it over a lamp (using tin plate and asbestos), not allowing it to become darker than amber color. When it is melted remove the lamp, leave the beaker in position (or hold the t.t. in the hand), and when crystals begin to shoot across the surface, pour some of the liquid S remaining into the water in an e.d., and watch the residue.

Loosen the S by pouring round the edges a little HNO_3. Warm, if necessary, when the mass may be removed with a thin knife-blade.

II. ALLOTROPY.

Put 10^g S into a t.t. and *slowly* melt it. Notice the yellow color, and see that the liquid (now above 100°) is very thin. Slowly continue to heat it till it becomes black. Note that it is now very thick and can scarcely be poured (about 200°). Apply more heat till it grows thin again (above 300°). Now heat to boiling (over 400°), note the color of the vapor, and any sublimate on the t.t. If it takes fire (S burns at 230°), cover the mouth of the tube with paper or cardboard for a minute. Pour the S into an e.d. of water. Pull it, and note its elasticity. Is it now crystalline, or amorphorous? See whether it afterward changes. Clean the t.t. as before.

III. SOLUBILITY.

Place in an e.d. $\frac{1}{2}^g$ pulverized brimstone and cover it with CS_2 (avoid a flame, as CS_2 is explosively inflammable). See whether any dissolves. Let it stand till the CS_2 has evaporated, watching it meantime. Describe fully the phenomena.

69. SULFUR DIOXID.

Supplies: wide-mouth bottle, lamp, combustion cup, flower, sulfur, $K_2Cr_2O_7$ sol.

1. Into a combustion cup place a piece of sulfur half the size of a pea. Put into a rec. a green leaf or colored flower moistened with water. Direct a flame upon the S until it burns, then lower the cup and S into the rec., keeping the latter nearly covered with a glass plate to confine the fumes.

2. After a minute or two take out the cup, and leave the rec. covered for some time.

3. State the color of the flame; the color, state, and name of the product. *Cautiously* try the odor. Write the equation.

4. On a strip of glazed white paper put a drop of a solution of potassium bichromate, $K_2Cr_2O_7$, and hold it in the fumes of the gas for a minute or more. Note the effect. The chromium compound has been reduced to chromic sulfate, $Cr_2(SO_4)_3$.

5. Note whether any change has taken place in the leaf, and explain.

6. In what other exps. have you noted the formation of SO_2?

70. HYDROGEN SULFID.

Supplies: test tubes, app. in Fig. 47, litmus paper, silver coin, s.r., sol. of $Pb(C_2H_3O_2)_2$, FeS, HCl.

1. Into a large t.t. pour about 10^{cc} of H_2S sol. (made in a gas gen., Fig. 47, by the action of HCl on ferrous sulfid, FeS, with H_2O, the preparation of which, with equation, should be described).

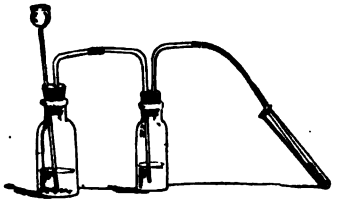


Fig. 47.

2. Pour 4 or 5^{cc} of it from the tube into an e.d., and put in a piece of blue and one of red litmus paper. Leave it for some time, noticing the effect, and stating what it shows, meanwhile noting the odor of the gas and doing the following.

3. With a s.r. put a drop of H_2S sol. on a silver coin. Describe the effect, with explanation and equation, and the name of the product.

4. Obtain a drop of lead acetate sol., $Pb(C_2H_3O_2)_2$, on the stopper of the bottle which holds it, and put it on a clean piece of paper. Note that it is colorless. Now warm a little of the H_2S sol., and while the tube is in the flame hold the lead paper near the open mouth of the tube so as to intercept the fumes. Notice any change, give the color, and explain, with equation. This is the characteristic test for H_2S.

5. See what parts of the above exps. illustrate the Law of Gases (Exp. 47), and what the Law of Precipitation (Exp. 37).

71. HYDROGEN SULFID.

Supplies: test tubes, sols. as in table below.

1. Fill a large t.t. half or two-thirds full of H_2S sol. (Exp. 70), and add 3 or 4^{cc} of it to each of the following sols. in separate test tubes. Fill out the table, stating in which cases there is a ppt., and in which none forms. On the opposite page write the equation where a precipitate is formed, underlining the ppt.

	Ppt. or Sol.	Color of Ppt.	Sym. of Ppt.
$CuCl_2$			
$CaCl_2$			
$AsCl_3$			
$PbCl_2$			
$AlCl_3$			
$SbCl_3$			
$BaCl_2$			

2. Make a mixture of solutions of $CuCl_2$ and $CaCl_2$, 3 or 4^{cc} of each, and try to separate the Cu from the Ca with H_2S. Describe fully. After filtering the ppt., add to the filtrate a sol. of sodium carbonate, Na_2CO_3, and state the result, with an equation. Why is no precipitate found in certain of the above cases? What does a precipitate indicate in regard to solubility? Examine Table A for soluble and insoluble sulfids.

72. SPONTANEOUS COMBUSTION OF PHOSPHOROUS.

Supplies: e.d., glass tube, CS_2, phosphorous.

1. For a small class of pupils, pour 10 or 20^{cc} of carbon disulfid, CS_2, into an e.d. (keep it away from any flame).

2. Observe its color, odor, and volatility, and that it is composed of two elements which are stable solids. To show its inflammability dip a glass tube into the liquid, and bring the tube to a flame; at once remove it, note the color and parts of the flame, the odor of the product and any deposit, and write the equation.

3. Drop into the liquid — for a class — 3 or 4 pieces of phosphorous as large as a pea. Note whether there is effervescence or other sign of chemical action. See whether the P gradually disappears, and explain the meaning of the action.

4. Dip one end of a piece of paper into the sol., and hold it in the air till the CS_2 evaporates, watching carefully for any phenomena. Describe fully, and explain every part. Give the color and the odor of the product, also the equation. If the paper is only charred see whether any deposit is formed on it.

5. State how this exp. fulfils the conditions of combustion. Enumerate other exps. which you have made with phosphorus, and from them state some of the properties of the element.

73. ARSENIOUS OXID AND CARBON.

Supplies: As_4O_6, powdered charcoal, NaClO, ignition tube, lamp.

1. Put on a paper, with the point of a pen-knife, as much arsenious oxid, As_4O_6, as is about equivalent to a grain of wheat, and mix it thoroughly with twice its bulk of powdered charcoal.

2. Pour the mixture from the paper into a very small and perfectly dry t.t. or i.t. Heat this for a moment in a Bunsen flame, and note all phenomena while the mixture is heating, including the odor of the escaping gas (describe it). This is characteristic of burning arsenic.

3. Examine the tube very fully, hold it in direct sunlight, and look for any shining particles (crystals). Describe the sublimate if there is one, giving the color or colors, the luster, etc.

4. State what was the agency of the carbon in this exp., and write two equations for the formation of different compounds of it. Explain all the phenomena.

5. The sublimate may be removed by vaporizing it again and driving it out of the tube, or by dissolving it (after removing the carbon) in NaClO, or aqua regia.

6. What previous exp. showed a similar action of carbon? Explain sublimation, sublimate, reducing agent, oxidizing agent. State what in the above exp. illustrates each of these terms.

74. REINSCH'S TEST FOR ARSENIC.

Supplies: shipping tag (green), copper, HCl, e.d., t.t., lamp.

1. Either dissolve in HCl, using an e.d., the coloring matter from 2 or 3^{qcm} of paper or other substance to be tested for arsenic, or pour into the e.d. 3 or 4^{cc} of sodium arsenite sol., Na_3AsO_3, strongly acidified with HCl.

2. Now put into this sol. a strip of bright copper foil, about 2×3^{cm}, and boil the sol. 2 or 3 minutes. Note whether the copper becomes discolored; if not, no As is present. If it does, remove the Cu, rinse it, press it lightly between the folds of filter paper to dry it. Then cut it into small strips, put these into a narrow t.t. or i.t., and heat slowly in a Bunsen flame.

3. Look for any change in the color of the copper, any sublimate (state its color and why it should differ from the sublimed As in Exps. 73, 75). The forms of crystals, as seen under a microscope, determine whether the substance is arsenic. The crystals are As_4O_6 and are octahedrons, tetrahedrons, etc., Fig. 48.

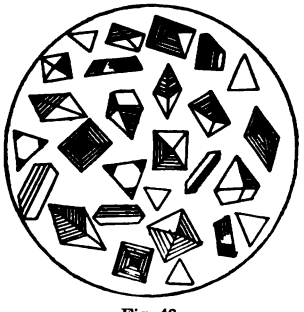


Fig. 48.

4. Write equations for the reactions in the exp., supposing the compound of arsenic in the paper to be AsX_3, in which X represents any negative element or radical with valence one.

Marsh's and Reinsch's tests are the most commonly employed for the detection of arsenic.

75. MARSH'S TEST FOR ARSENIC.

Supplies: app. in Fig. 49, arsenic-free zinc, HCl, paper for testing, e.d., lamp.

[N.B. All directions in this exp. must be closely followed, as the gas AsH_3 is a deadly poison and must be kept within the apparatus till burned.]

1. Arrange a gas gen. as in Fig. 49, having a $CaCl_2$ dryer (3 or 4 in. long) and a capillary tube of hard glass, with small opening at the end.

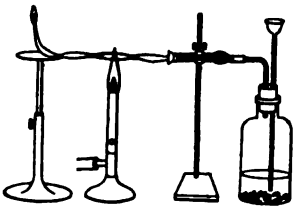


Fig. 49.

2. Put into the gen. 10 or 15g of arsenic-free zinc, cover the latter well with H_2O (preferably distilled), and add C.P. hydrochloric acid in small successive quantities through the thistle tube. Test the gas before lighting it (Exp. 22), then light it when the air is expelled, but meanwhile do 3.

3. Dissolve the coloring matter from a small piece (not over 2 or 3qcm) of a green card tag (or other substance supposed to contain arsenic), by pouring over it in an e.d. 4 or 5cc of HCl, and stirring it up for a minute or two, then removing the paper.

4. After lighting the gas (note the color, etc.) pour this sol. into the tube (add more HCl, if necessary, to make a brisk flame), and place a Bunsen lamp under the wide part of the capillary tube. Note whether there is any sublimate in the capillary tube. If so, remove the lamp, and note any change in the color of the flame. Also hold the inside of an e.d. in the flame, and in a moment look for a deposit. In case all these results are negative, no arsenic is likely to be present in the substance analyzed. A few drops of sodium arsenite, Na_3AsO_3 sol., or of Paris green sol. (dissolved in H_2O and HCl) will give the As test.

5. To distinguish the As sublimate from one of Sb which closely resembles it, break the tube near the sublimate and dip it into a little sodium hypochlorite, NaClO, which quickly dissolves As but not Sb.

6. Clean the apparatus (*avoid inhaling the gas* AsH_3), and wash and return the zinc to a special receptacle.

7. Describe the phenomena, and write all the equations.

76. SILICIC ACID AND SILICA FROM WATER GLASS.

Supplies: water glass, HCl, NaOH, e.d., lamp.

1. Pour into an e.d. about 5^{cc} of water glass (*i.e.*, liquid sodium silicate, Na_4SiO_4, or potassium silicate K_4SiO_4), and add the same volume of HCl. Describe the effect, and write the equation. Pour off the excess of HCl, rinse the substance in the dish to remove all HCl, press some of the substance with the fingers, describe and name it.

2. Heat the residue, and notice the change which takes place. Describe it, and when the substance becomes hard (losing all its H_2O), extinguish the flame. Note the color, texture, etc. Write the equation.

3. When it is cool, crush some between the fingers, and describe, comparing it with anything you recall of a similar nature. Now add 10^{cc} of H_2O, stir it a minute, taste a drop of the water, and pour off the latter, leaving the residue, which is silica.

4. Remove from the e.d. any adhering silica with strong NaOH sol., heating it, if necessary.

5. Recall any exp. for dissolving silica. Examine different varieties of silica, as quartz, flint, sand, etc., also of silicates, as glass, mica, and feldspar.

77. OXIDATION OF FERROUS TO FERRIC SALTS, Fe″ to Fe‴.

Supplies: $FeSO_4$, $FeCl_3$ (and sols. of same), NH_4OH, HNO_3, sols. of K_4FeCy_6, K_3FeCy_6, KSCy, test tubes.

1. Examine some ferrous salt (as crystals of pure $FeSO_4$), also a ferric salt (as $FeCl_3$), noting the difference in color, in valence of Fe, and in name.

2. Pour into a t.t. 5^{cc} of a sol. of ferrous sulfate, $FeSO_4$, and into another 5^{cc} of ferric chlorid sol., $FeCl_3$. To each add a small quantity of ammonium hydrate, NH_4OH. Shake the mixture, and note the difference of color effects in the two products, explain, and give the equations, stating the ppt.

3. Now oxidize Fe″ to Fe‴ by taking 5^{cc} of $FeSO_4$ sol. in a t.t., adding a *few drops* of HNO_3, and boiling a few minutes. Note any change of color or other effect, and when the action stops, cool the liquid by holding the tube under a water jet, then add NH_4OH, and shake it.

4. State how this exp. shows whether the iron has been oxidized. If it has not been, boil it longer, adding a few drops more of acid, if necessary. Take note what the oxidizing agent here used is, and that oxidation consists in raising the valence of the metallic or positive element, or of increasing its capacity to hold negative elements in composition.

5. Test solutions of $FeSO_4$ and of $FeCl_3$ with the following solutions, and *tabulate the results:* potassium ferrocyanid, potassium ferricyanid, potassium sulfocyanid (a drop or two of the last, and 1 or 2^{cc} of the other two).

78. REDUCTION OF FERRIC TO FERROUS SALTS, Fe‴ to Fe″.

Supplies: $FeCl_3$ sol., Zn, HCl, NH_4OH, test tubes.

1. Into 5^{cc} of ferric chlorid sol., $FeCl_3$, in a t.t. put 2 or 3 pieces of zinc, and add a few drops of HCl. Observe any action, liberation of gas, change of color, etc. Let it stand for several minutes. If necessary, add more HCl or Zn.

2. Test some of the sol. when you think reduction has taken place, by pouring a little into another t.t. and adding NH_4OH. Give the result, stating how it shows whether Fe‴ has been reduced to Fe″, and what the reducing agent is.

3. Give the equation for the reduction, if possible, and also for the action of NH_4OH on the reduced product. Note that reduction is the opposite of oxidation, and consists in lowering the valence of the metallic or positive element of a compound, or in reducing its capacity to hold negative elements.

4. Notice the valence of Fe, of Hg, and of Sn in the *ous* and *ic* compounds below, also that oxidation or reduction changes one to the other.

1.	*ous.*	FeO,	$FeCl_2$,	$Fe(OH)_2$,	$FeSO_4$
	ic.	Fe_2O_3,	$FeCl_3$,	$Fe(OH)_3$,	$Fe_2(SO_4)_3$
2.	*ous.*	SnO,	$SnCl_2$,	$Sn(OH)_2$,	$SnSO_4$
	ic.	SnO_2,	$SnCl_4$,	$Sn(OH)_4$,	$Sn(SO_4)_2$
3.	*ous.*	Hg_2O,	$HgCl$,	—	Hg_2SO_4
	ic.	HgO,	$HgCl_2$,	—	$HgSO_4$

79. METALS—SILVER GROUP: Pb, Ag, Hg.

Chemicals: $Pb(NO_3)_2$, $AgNO_3$, $HgNO_3$, HCl, $K_2Cr_2O_7$, H_2SO_4, H_2S, NH_4OH, HNO_3, $SnCl_2$.

1. *Ppt. the Group.* To 5 or 10^{cc} of a mixture of sols. of $Pb(NO_3)_2$, $AgNO_3$, $HgNO_3$, add some dilute HCl (4 pts. H_2O to 1 of HCl), let the ppt. settle for a moment, then add a drop or two more. When no more new ppt. falls, shake the contents and filter. Test the filtrate with a drop or two of HCl, to see whether all the metals have been precipitated. If not, add more HCl. The residue contains all the metals as chlorids, $PbCl_2$, AgCl, HgCl. Reject the filtrate, and wash the residue once by pouring on about 5^{cc} of cold water and letting it run through the filter.

2. *Separate Pb.* Punch a hole in the filter paper with a clean stirring rod, and wash the residue into a clean t.t., using a fine spray of water from a wash bottle. Then prepare a clean filter. When the solid has settled, pour off the water all but 10 or 12^{cc}, and boil the latter with the solid matter. Pour it *while hot* on a clean filter, and catch the filtrate in a clean t.t. Hot water dissolves $PbCl_2$, and hence the most of the Pb will be in the filtrate, separated from the Ag and Hg, as hot water does not affect them.

3. *Test the filtrate for Pb.* To the filtrate add $K_2Cr_2O_7$ sol. A yellow ppt. is $PbCrO_4$.

4. *Separate Ag from Hg.* Pour on the filter a small quantity of NH_4OH, and catch the filtrate in a clean t.t. AgCl is soluble in NH_4OH. (A slight white ppt. contains Pb which was not all removed. It must be re-filtered.)

5. *Test the filtrate for Ag.* Cautiously acidify it with HNO_3. White AgCl ppts.

6. *Test for Hg.* Note the color of the residue (from 4). It indicates a compound of Hg. All the metals in this group have now been separated. Make tables as follows:

Sol.	Reagt. 1	Ppt. 1	Color	Solvent	Reagt. 2	Ppt. 2	Color

7. Analyze one or more "unknowns," given by the teacher.

80. METALS—COPPER GROUP: Hg (ic), Pb, Bi, Cd, Cu.

Chemicals: $HgCl_2$, $PbCl_2$, $BiCl_3$, $CdCl_2$, $CuCl_2$, $SnCl_2$, H_2S, HNO_3, HCl, H_2SO_4, C_2H_5OH, NH_4OH, KCN.

1. *Precipitate the Group.* Sat. 5 or 10^{cc} of a mixture of sols. of $HgCl_2$, $PbCl_2$, $BiCl_3$, $CdCl_2$, $CuCl_2$ with H_2S gas. Ppt. is HgS, PbS, Bi_2S_3, CdS, CuS. Filter (test fil.), wash the res. 2 or 3 times. Open the filter, and remove the res. with a spatula to an e.d.

2. *Separate Hg.* Cover the res. well with dil. HNO_3, boil and stir it 2 or 3 minutes, adding more acid, if necessary. An insol. res. is HgS (and S set free). Sol. contains $Pb(NO_3)_2$, $Bi(NO_3)_3$, $Cd(NO_3)_2$, $Cu(NO_3)_2$. Decant it upon a filter, leaving the res. in the e.d.

3. *Dissolve and test for Hg.* Add to the res. very little aqua regia, and stir it. Sol. contains $HgCl_2$. Black or yellow res. is S. Filter, and to fil. add $SnCl_2$ sol. White ppt. is HgCl, gray is Hg.

4. *Separate Pb.* To fil. (from 3) add dil. H_2SO_4 and alcohol, and shake them. A white ppt. is $PbSO_4$. Filter. The fil. contains $Bi(NO_3)_3$, $Cd(NO_3)_2$, $Cu(NO_3)_2$.

5. *Separate Bi.* Add to the filtrate NH_4OH. A white, flaky ppt. is $Bi(OH)_3$. Filter. The filtrate contains $(NH_3)_2CdO(NH_4NO_3)_2$ and $(NH_3)_2CuO(NH_4NO_3)_2$.

6. *Separate Cd.* Add to the filtrate just enough KCN sol. to decolorize the blue copper salt. $K_2Cd(CN)_4$ and $K_2Cu(CN)_4$ are formed and dissolved. Saturate this sol. with H_2S. A yellow ppt. is CdS. Filter. The filtrate contains $K_2Cu(CN)_4$.

7. *Test for Cu.* Acidify the filtrate with HCl. A black ppt. is CuS.

8. Make a table, as in Exp. 79. Also commit to memory the method of separating the members of this group, and of subsequent ones as they are reached.

81. METALS—TIN GROUP: As, Sb, Sn.

Chemicals: $AsCl_3$, $SbCl_3$, $SnCl_2$, H_2S, $(NH_4)_2CO_3$, Zn, NaClO, HCl, $HgCl_2$.

1. *Precipitate the Group.* Saturate 5 or 10^{cc} of a mixture of sols. of $AsCl_3$, $SbCl_3$, $SnCl_2$ with H_2S. A ppt. is As_2S_3, Sb_2S_3, SnS. Filter, and wash the ppt.

2. *Separate As.* Cover the res. in an e.d. with HCl, warm and stir for some time, till lead acetate paper shows no H_2S present; but do not boil it. Residue is As_2S_3 (and S). Decant on a filter. Filtrate contains $SnCl_2$ and $SbCl_3$.

3. *Test for As.* Add to the residue $(NH_4)_2CO_3$ sol., and stir it well. Sol. contains $(NH_4)_3AsS_3$. Filter from residual S, if necessary. To filtrate add HCl. A yellow ppt. is As_2S_3.

4. *Test for Sn.* Divide the filtrate (from 2) into two parts. To one add $HgCl_2$ sol. A white ppt. is HgCl, a gray one is Hg. Either shows the presence of Sn.

5. *Test for Sb.* Prepare a hydrogen gen. with *a little* C.P. zinc and HCl, a $CaCl_2$ dryer, and capillary attachment (Exp. 75). Put in also a small piece of Pt foil (*e.g.*, 3^{cm} square). After the usual precaution, light the gas, then pour in the second part. Place a Bunsen flame near the narrow part of the capillary tube, and notice the sublimate (Sb). When no more sublimate forms, extinguish the flame, remove and break the capillary, and try to dissolve the Sb in NaClO sol. in an e.d. It does not dissolve, showing it to be Sb, not As.

82. METALS—IRON GROUP: Fe, Al, Cr.

Chemicals: $FeCl_3$, $AlCl_3$, $CrCl_3$, NH_4OH, HNO_3, $KClO_3$, $NaOH$, HCl, $HC_2H_3O_2$, $Pb(C_2H_3O_2)_2$.

1. *Precipitate the Group.* Add to a mixture of sols. of $FeCl_3$, $AlCl_3$, $CrCl_3$ some NH_4OH. The ppt. is $Fe(OH)_3$, $Al(OH)_3$, $Cr(OH)_3$. Filter, and wash the residue.

2. *Dissolve the Precipitate.* Dissolve the res. in a little dilute HNO_3. Sol. contains $Fe(NO_3)_3$, $Al(NO_3)_3$, $Cr(NO_3)_3$.

3. *Oxidize Cr.* Oxidize the chromic salt to a chromate (Cr''' to Cr^{vi}), by half evaporating the sol. in an e.d., then adding 1 or 2 crystals of $KClO_3$, evaporating again to a few drops, and putting in more $KClO_3$. When it is wholly evaporated, add a little H_2O. If the residue was not distinctly red, it must be further evaporated, with $KClO_3$ added at the end. The sol. then contains $Fe(NO_3)_3$, $Al(NO_3)_3$, $K_2Cr_2O_7$. Pour into a t.t. The oxidation of Cr prevents its ppn. by NaOH.

4. *Separate Fe.* To the sol. add excess of NaOH sol. A red-brown ppt. is $Fe(OH)_3$. Filter. The fil. contains Na_2AlO_4, Na_2CrO_4. Unless excess of strong NaOH was used, Al would ppt. with Fe.

5. *Separate Al.* Acidify the filtrate with HCl, then alkalize it with NH_4OH. A white, flaky ppt. is $Al(OH)_3$. The sol. contains Na_2CrO_4. Some H_4SiO_4 may ppt. here also, made by the action of NaOH on the SiO_2 of the bottle containing it. Filter.

6. *Test for Cr.* Acidify the filtrate with $HC_2H_3O_2$, and add $Pb(C_2H_3O_2)_2$ sol. A yellow or reddish ppt. is $PbCrO_4$. If the ppt. is white, it shows no Cr, but is likely to be $PbCl_2$ from the reagents.

83. METALS—ZINC GROUP: Co, Ni, Mn, Zn.

Chemicals: $CoCl_2$, $NiCl_2$, $MnCl_2$, $ZnCl_2$, $(NH_4)_2S$, HCl, HNO_3.

1. *Precipitate the Group.* To 5 or 10^{cc} of a mixture of sols. of $CoCl_2$, $NiCl_2$, $MnCl_2$, $ZnCl_2$, add some $(NH_4)_2S$, shake, and warm it, without boiling. A ppt. is CoS, NiS, MnS, ZnS. Filter (test filtrate), and at once pour on the res. a few drops of $(NH_4)_2S$ (to prevent oxidation of CoS and NiS), and wash once with hot water.

2. *Separate Mn and Zn.* Transfer the res. to an e.d., cover well with dil. HCl, and stir it two or three minutes, then filter (decant if possible). The res. is CoS and NiS. Filtrate contains $MnCl_2$ and $ZnCl_2$.

3. *Dissolve CoS and NiS.* Add a few drops of aqua regia, and stir it. The sol. contains $CoCl_2$ and $NiCl_2$. Evap. the free acid, and add H_2O. Filter, if necessary.

4. *Separate Co.* Acidify with $HC_2H_3O_2$, add KNO_2 sol., and leave 24 hours. A yellow ppt. is $K_6Co_2O(NO_2)_{10}$. Filter. Filtrate contains $NiCl_2$.

5. *Test for Ni.* Add to the filtrate NaOH sol. A greenish, flaky ppt. is $Ni(OH)_2$.

6. *Separate Mn.* Boil the filtrate (from 2), to expel any H_2S or NH_3, add excess of NaOH sol., shake, and let it stand a few minutes. A ppt., if white, is $Mn(OH)_2$, if brown, $Mn_2O_2(OH)_2$. Filter. The sol. contains Na_2ZnO_2. NaOH first ppts. $Zn(OH)_2$, soluble in excess of strong NaOH.

7. *Test for Zn.* Acidify filtrate with $HC_2H_3O_2$, and add $(NH_4)_2S$. A white ppt. is ZnS.

84. METALS—BARIUM GROUP: Ba, Sr, Ca, Mg.

Chemicals: $BaCl_2$, $SrCl_2$, $CaCl_2$, $MgCl_2$, NH_4Cl, NH_4OH, $(NH_4)_2CO_3$, HNa_2PO_4, $HC_2H_3O_2$, $K_2Cr_2O_7$, $(NH_4)_2SO_4$, $(NH_4)_2C_2O_4$.

1. *Separate Mg, and ppt. Ba, Sr, Ca.* To 5 or 10^{cc} of a mixture of sols. of $BaCl_2$, $SrCl_2$, $CaCl_2$, $MgCl_2$, add NH_4Cl sol. (avoid excess), NH_4OH, and $(NH_4)_2CO_3$ sol. Shake and warm it. A white ppt. is $BaCO_3$, $SrCO_3$, $CaCO_3$. Filter (test filtrate with $(NH_4)_2CO_3$). Filtrate contains $(NH_4)_2MgCl_4$. (NH_4Cl prevents the precipitation of Mg by NH_4OH.)

2. *Test for Mg.* To the filtrate add HNa_2PO_4 sol. A white ppt. is NH_4MgPO_4. (NH_4OH, added in 1, aids precipitation of this.)

3. *Separate Ba.* Dis. the res. (from 1) in $HC_2H_3O_2$, then add $K_2Cr_2O_7$ sol. A yellow ppt. is $BaCrO_4$. Filter (test filtrate). Filtrate contains $Sr(C_2H_3O_2)_2$ and $Ca(C_2H_3O_2)_2$.

4. *Test for Sr.* To a little of the filtrate add a saturated sol. of $CaSO_4$. If a white ppt., $SrSO_4$, falls, treat the remainder of the sol. as in 5. But if no ppt. falls, Sr is absent, and the remainder is treated as in 6.

5. *Separate Sr.* To the sol. in 4 (in which Sr was found present) add strong $(NH_4)_2SO_4$ sol. A white ppt. is $SrSO_4$ (with some $CaSO_4$). Filter, and treat the filtrate as in 6.

6. *Test for Ca.* To the sol. in 4 (in which Sr was found absent) or the filtrate in 5, add $(NH_4)_2C_2O_4$ sol. A white ppt. is CaC_2O_4.

84. METALS—BARIUM GROUP: *Ba, Sr, Ca, Mg.*

Chemicals: $BaCl_2$, $SrCl_2$, $CaCl_2$, $MgCl_2$, NH_4Cl, NH_4OH, $(NH_4)_2CO_3$, HNa_2PO_4, $HC_2H_3O_2$, $K_2Cr_2O_7$, $(NH_4)_2SO_4$, $(NH_4)_2C_2O_4$.

1. *Separate Mg, and ppt. Ba, Sr, Ca.* To 5 or 10cc of a mixture of sols. of $BaCl_2$, $SrCl_2$, $CaCl_2$, $MgCl_2$, add NH_4Cl sol. (avoid excess), NH_4OH, and $(NH_4)_2CO_3$ sol. Shake and warm it. A white ppt. is $BaCO_3$, $SrCO_3$, $CaCO_3$. Filter (test filtrate with $(NH_4)_2CO_3$). *Filtrate* contains $(NH_4)_2MgCl_4$. (NH_4Cl prevents the *precipitation* of Mg by NH_4OH.)

2. *Test for Mg.* To the filtrate add HNa_2PO_4 sol. A white ppt. is NH_4MgPO_4. (NH_4OH, added in 1, aids precipitation of this.)

3. *Separate Ba.* Dis. the res. (from 1) in $HC_2H_3O_2$, then add $K_2Cr_2O_7$ sol. A yellow ppt. is $BaCrO_4$. Filter (test filtrate). Filtrate contains $Sr(C_2H_3O_2)_2$ and $Ca(C_2H_3O_2)_2$.

4. *Test for Sr.* To a little of the filtrate add a saturated sol. of $CaSO_4$. If a white ppt., $SrSO_4$, falls, treat the remainder of the sol. as in 5. But if no ppt. falls, Sr is absent, and the remainder is treated as in 6.

5. *Separate Sr.* To the sol. in 4 (*in which Sr was found present*) add strong $(NH_4)_2SO_4$ sol. A white ppt. is $SrSO_4$ (with some $CaSO_4$). Filter, and treat the filtrate as in 6.

6. *Test for Ca.* To the sol. in 4 (*in which Sr was found absent*) or the filtrate in 5, add $(NH_4)_2C_2O_4$. A white ppt. is CaC_2O_4.

85. SEPARATION OF THE GROUPS.

Chemicals: members of previous groups, HCl, H_2S, $(NH_4)_2S_x$, NH_4Cl, NH_4OH, $(NH_4)_2CO_3$, $(NH_4)_2S$.

1. *Separate the Ag Group.* To 10^{cc} of the sol. add dil. HCl. A ppt. contains some of the Ag group. Filter, and test the residue by Exp. 79. The filtrate may contain any or all of the other groups.

2. *Separate the Cu and Sn Groups.* Saturate the sol. with H_2S. A ppt. contains some of the Cu or Sn groups. The filtrate may contain any of the subsequent groups. (Label it for 3.) Filter and wash the residue, then add $(NH_4)_2S_x$ in an e.d., stir and warm it some time, then filter. The residue contains the Cu group. Analyze it by Exp. 80. The filtrate may contain members of the Sn group. Acidify this filtrate with HCl and reppt. the Sn group. Analyze it by Exp. 81.

3. *Separate the Fe Group.* Add to the filtrate (from 2) NH_4Cl sol. and NH_4OH. (NH_4Cl prevents ppn. of Mn, Zn, Co, Ni, Mg, by NH_4OH.) A ppt. should contain the Fe group. Analyze by Exp. 82. Filter. The filtrate may contain the Zn or Ba group.

4. *Separate the Zn Group.* To the filtrate add $(NH_4)_2S$. A ppt. should have members of the Zn group. Filter, and analyze the residue by Exp. 83. The filtrate may have the Ba group.

5. *Test for the Ba Group* by Exp. 84.

86. METALS—SODIUM GROUP: Na, K, NH_4.

Chemicals: NaCl, KCl, $PtCl_4$, NaOH, Nessler's sol.

All the common salts of these metals are soluble, hence none of the ordinary reagents ppt. them. Each must be tested for, and from some of the original sol.

1. *Sodium.* Moisten a Pt wire, dip it into a very little fine NaCl, or into a sol. of the same, and hold the wire in the outer edge of a Bunsen flame. The flame is tinged a bright orange-yellow. Hold a cobalt blue glass between your eye and the flame. The color is almost or wholly obscured.

2. *Potassium.* (*a*) Dip the wire into some fine KCl, or a sol. of it, and hold it, as before, in the outer flame. A blue or purple flame appears. Blue glass does not interfere with this flame. (*b*) To a little KCl sol. add a drop or two of $PtCl_4$ sol. K_2PtCl_6 (yellow) ppts.

3. *Ammonium.* (*a*) Add a drop or two of $PtCl_4$ sol. to a few cc. of NH_4Cl sol. in a t.t. Yellow $(NH_4)_2PtCl_6$ ppts. (*b*) To a few more cc. add 1 or 2 drops of Nessler's sol. A brownish ppt. is NHg_2IH_2O. (*c*) Add to some of the ammonium compound (preferably in the form of a solid) some NaOH sol., warm it, and note the odor of the escaping gas. It is NH_3. Also bring near the open mouth of the tube a few drops of HCl in an e.d. White fumes of NH_4Cl appear.

87. ACID RADICALS—NITRATES.

Chemicals: $Pb(NO_3)_2$, KNO_3, $NaNO_3$, $FeSO_4$, H_2SO_4, HNO_3, Cu, indigo.

1. *Red Fumes Test.* Put into an i.t. or a small t.t. half a gram of fine $Pb(NO_3)_2$. Heat it, meanwhile thrusting a glowing splint into the tube. Red fumes, NO_2 and N_2O_3, come off; also O, in which the splint burns.

2. *Deflagration Test.* Mix about half a gram of powdered KNO_3, or other nitrate with an equal quantity of powdered charcoal. Put the mixture into an i.t. or a t.t., and cautiously heat the contents. Vigorous deflagration ensues. Compare this result with the test for chlorates.

3. *Copperas Test.* Pour into a t.t. 5^{cc} of $NaNO_3$ sol. and a little fresh sol. of $FeSO_4$. Run a thistle tube to the bottom of this test tube and pour a few drops of H_2SO_4 into it. Look for a brown halo or ring at the junction of the two liquids before taking out the thistle tube.

4. *Free Nitric Acid.* (*a*) Add a few drops of HNO_3 to some indigo sol. Warm it, if necessary. The indigo sol. is decolorized or changed to reddish isatin. (*b*) Put a drop of HNO_3 with a s.r. on the finger nail, wash it off, and add a drop of NH_4OH. Or treat a feather in the same way. HNO_3 turns animal matter yellow. (*c*) Pour a little HNO_3 on Cu filings. Warm it, if necessary. Red fumes (NO_2) and a green liquid ($Cu(NO_3)_2$) are formed.

88. ACID RADICALS—CHLORATES.

Chemicals: $KClO_3$, $AgNO_3$, H_2SO_4, H_2SO_3, indigo, charcoal.

1. *Oxygen Test.* Heat about half a gram of $KClO_3$ in an i.t. or a small t.t. Meanwhile thrust a glowing splint into the tube. The salt first melts, then breaks up into KCl and O. The later rekindles a glowing splint. Cool the residue, KCl, dissolve some of it in H_2O, and add a drop or two of $AgNO_3$ sol. A white ppt. of AgCl falls. Test some of the original $KClO_3$ in the same way, and no ppt. is obtained, if the salt is pure.

2. *Deflagration Test.* Powder and mix about half a gram of $KClO_3$ with the same amount of powdered charcoal, put into an i.t. or a small t.t., and heat. It burns with deflagration. Compare this with a nitrate.

3. *Explosion Test.* To about half a gram of powdered $KClO_3$ add cautiously (holding the t.t. at arm's length) a few drops of H_2SO_4. The $KClO_3$ explodes, liberating the yellow gas ClO_2. Fill at once with water.

4. *Bleaching Test.* (*a*) To a sol. of indigo add a very little $KClO_3$, either as solution or solid, and heat it. The indigo is changed to red isatin. Compare this with the test for nitrates. (*b*) Mix a sol. of $KClO_3$ and H_2SO_3 with indigo without heating, and the same effect is produced.

89. ACID RADICALS—CARBONATES.

Chemicals: $CaCO_3$, Na_2CO_3, $Ca(OH)_2$, HCl, $Ba(OH)_2$.

1. *Lime-Water Test.* As any common acid, except H_2S and HCN, will act on a carbonate and liberate CO_2, we have only to test the escaping gas on adding an acid to a carbonate. Put into a t.t. or gas gen. (Exp. 55, Fig. 41) a little $CaCO_3$ or other carbonate, cover it with water, add a small quantity of HCl, and pass the gas into lime-water, $Ca(OH)_2$ sol., in another t.t. A white ppt. of $CaCO_3$ forms, soluble in excess of CO_2 and H_2O, or in acids.

2. *Barium Hydroxid Test.* Apply this in the same way as the lime-water test, using $Ba(OH)_2$ sol. instead of $Ca(OH)_2$. White $BaCO_3$ falls, soluble with effervescence in dilute HCl, or in excess of CO_2.

3. *Flame Test.* Put a burning splint into the gas generated as above. Would this distinguish it from N, SO_2, etc.?

4. State how you could distinguish CO_2 from O, N, H, CO, N_2O, NO, NO_2, N_2O_3, SO_2, NH_3, H_2S, giving the test for each of the gases. Test some clam (or other) shells to see whether they contain any carbonates.

90. ACID RADICALS—SULFIDS.

Chemicals: FeS, HCl, $Pb(C_2H_3O_2)_2$, Na_2S, Ag, sols. given in (3) below.

1. *Hydrogen Sulfid Test.* An acid acting on a sulfid liberates H_2S, which is then tested. Put a small piece of FeS (or other sulfid) in a t.t., cover it with H_2O, and add a little HCl. Put a drop of lead acetate sol. on a piece of paper, and hold it over the t.t. in the escaping gas. H_2S is formed by action of the acid, and this blackens the lead acetate sol., forming PbS, and has the odor of sewer gas.

2. *Coin Test.* On a silver coin put a drop of water, and in this put a small piece of Na_2S, or other soluble sulfid, and leave for some time. The coin is blackened by formation of Ag_2S. If the sulfid is insoluble it must first be powdered, mixed with Na_2CO_3, fused on charcoal with a blowpipe, and then placed with a drop of water on silver.

3. *Precipitation Test.* Liberate the gas with HCl as before, and pass it into sols. of (1) $Pb(NO_3)_2$, (2) $AgNO_3$, (3) $HgNO_3$, (4) $HgCl_2$, (5) $BiCl_3$, (6) $CdCl_2$, (7) $CuCl_2$, (8) $AsCl_3$, (9) $SbCl_3$, (10) $SnCl_2$. Ppts. will form as follows: (1), (2), (3), (4), (5) black, (6), (8) yellow, (7) brown to black, (9) orange-red, (10) dark brown (Exps. 79, 80, 81).

91. ACID RADICALS—CHLORIDS.

Chemicals: NaCl, H_2SO_4, NH_4OH, MnO_2, indigo, $Pb(NO_3)_2$, $AgNO_3$, $HgNO_3$, HNO_3.

1. *HCl Test.* To a little NaCl in a t.t. add a small quantity of H_2SO_4, warm it, and test the escaping gas (cautiously take the odor, and bring a few drops of NH_4OH in an e.d. near the mouth of the t.t.). HCl is liberated, giving white fumes with NH_3.

2. *Chlorin Test.* Mix a very little NaCl, or other solid chlorid, with an equivalent amount of MnO_2, pour over it in a t.t. some H_2SO_4, and warm the mixture. A greenish-yellow gas of characteristic odor will escape and form white fumes with NH_3. Put a drop of indigo sol. on paper, and hold it in the fumes. It is bleached.

3. *Precipitation Test.* Make a solution of the chlorid, and add a few drops of this to each of these separately: (*a*) $AgNO_3$, (*b*) $Pb(NO_3)_2$, (*c*) $HgNO_3$. Each will give a white ppt. To (*a*) add NH_4OH, which will dissolve the ppt. Then add HNO_3, which will reppt. it. Boil (*b*). This should dissolve all or nearly all of it. Cool it under a water jet, and notice the recurrence of the ppt. To (*c*) add NH_4OH, and notice the color of the ppt. has been turned black.

92. ACID RADICALS—BROMIDS.

Chemicals: KBr, MnO_2, H_2SO_4, starch, $AgNO_3$, HNO_3, NH_4OH, CS_2, $KClO_3$, HCl.

1. *Bromin Test.* Mix 3 or 4 crystals of KBr, or other bromid, with an equal quantity of MnO_2, pour in a few drops of H_2SO_4, and apply heat. The red gas Br is liberated. Test the gas by holding at the mouth of the tube a paper dipped in starch sol. (Exp. 65), or better, by pouring a very little gas into a t.t. having some starch sol. The latter is turned yellow, starch bromid being formed. Test it also by using a paper dipped in a mixture of starch and a drop or 2 of KI sol. Blue starch iodid is formed.

2. *Silver Nitrate Test.* Pour a drop or two of $AgNO_3$ sol. into a sol. of KBr, or other bromid. Yellowish-white AgBr ppts. Try to dissolve a part of it in HNO_3, another in NH_4OH. The latter slowly dissolves, the former does not.

3. *Carbon Disulfid Test.* Pour 1 or 2 drops of CS_2 into a sol. of KBr. Add a drop of euchlorin (Exp. 64), and shake the mixture. Cl liberates Br, and the latter is absorbed by CS_2, which is colored yellow at the bottom of the sol.

93. ACID RADICALS—IODIDS.

Chemicals: KI, MnO_2, H_2SO_4, starch, CS_2, $KClO_3$, HCl.

1. *Iodin Test.* Mix 3 or 4 crystals of KI with an equal amount of MnO_2, add a few drops of H_2SO_4, and apply heat. Violet vapors of I appear. Hold some paper dipped in starch sol. in the fumes, or pour some of the I vapor into a cold sol. of starch. The starch is colored blue, starch iodid being formed (Exp. 67).

2. *Carbon Disulfid Test.* Into a t.t. containing a sol. of KI, or other iodid, pour a drop or two of CS_2 [or $(C_2H_5)_2O$], then 2 or 3 drops of euchlorin (Exp. 64), avoiding excess. Shake the tube well. CS_2 dissolves the I which has been set free by Cl, and is colored violet at the bottom of the tube.

94. ACID RADICALS—SULFATES.

Chemicals: Na_2SO_4, $BaCl_2$, HCl, $BaSO_4$, K_2CO_3, Na_2CO_3, H_2SO_4, sugar.

1. *Barium Test.* To some Na_2SO_4 sol., or other soluble sulfate, in a t.t. add a sol. of $BaCl_2$. A white ppt. of $BaSO_4$ falls. Let it settle, and then pour off the greater part of the supernatant liquid. To the residue add dilute HCl. The ppt. does not dissolve. $BaSO_4$ is the only salt of Ba that is insoluble in dilute HCl.

2. *Insoluble Sulfates.* Thoroughly mix 1 part of $BaSO_4$ with 2 parts of K_2CO_3 and 2 of Na_2CO_3 (not over 4 or 5g in all), fuse them in a porcelain crucible with a blast lamp (or in a Pt crucible, if no Ag, Pb, or S is present in the compound), or fuse the mixture on charcoal with the blowpipe. K_2SO_4, Na_2SO_4, and $BaCO_3$ are formed. Pulverize the product, and dissolve the first two in H_2O, decant the liquid on a filter, test the filtrate for a sulfate by the barium test. Dissolve the last one, $BaCO_3$ (which is the residue after dissolving the sulfates in H_2O), in HCl, and test it for Ba by Exp. 84.

3. *Free H_2SO_4.* (*a*) Place a drop on paper, and evaporate it high above a flame. The paper is pulped, rotted, or charred. (*b*) Put a few drops on a little sugar in an e.d., and warm it gently. A greenish or black substance is formed. The acid carbonizes the sugar.

95. ACID RADICALS—PHOSPHATES.

Chemicals: HNa_2PO_4, NH_4Cl, NH_4OH, $MgSO_4$, $HC_2H_3O_2$, $NaC_2H_3O_2$, $FeCl_3$, $AgNO_3$, HNO_3.

1. *Magnesium Test.* To a sol. of HNa_2PO_4, add some NH_4Cl sol., NH_4OH, and $MgSO_4$ sol., shake the mixture, warm it gently, and let it stand, if a ppt. is not formed at once. A white, crystalline ppt. of NH_4MgPO_4 is formed.

2. *Iron Test.* Add to a sol. of HNa_2PO_4, or other phosphate, a drop or two of $HC_2H_3O_2$, then some $NaC_2H_3O_2$ sol., and finally 1 or 2 drops of $FeCl_3$ sol. There falls a yellowish-white, gelatinous ppt., $FePO_4$.

3. *Silver Nitrate Test.* Add a drop or 2 of $AgNO_3$ sol. to a solution of HNa_2PO_4. Yellow Ag_3PO_4 falls, which is dissolved by HNO_3.

Unknowns. To test an unknown for an acid radical, put into a test tube a little of the solid and cautiously add a very little H_2SO_4. If no action takes place, cautiously heat it. Take note of the fumes — color, odor, etc. — and try to ascertain from them which of the acid radicals it contains. If there is no action of the H_2SO_4, apply the tests in 94 and 95. If there is action and you suspect any particular one of the radicals, turn to the experiment in question and make all the tests.

96. CONSERVATION OF MATTER. QUANTITATIVE.

Supplies: wide-mouth bottle, corks, forceps, balance, phosphorus.

1. Drop a small cork into a wide-mouth bottle so that it will stand upright on the bottom of the bottle. Place a small piece of phosphorus on this cork, then fit another cork to the mouth of the bottle so as to make it air-tight. Weigh the bottle and its contents very accurately, and make a record of the weight. The result is the combined weight of the bottle, corks, phosphorus, and the oxygen, nitrogen, etc., of the air.

2. Now set the phosphorus on fire, by placing the bottle in direct sunlight (or by focussing the sun's rays on it with a large lens). Notice the combustion, and the product.

3. When combustion stops, or has nearly stopped, weigh the bottle and its contents again. If no air has entered or escaped, the weight should be the same as before the reaction took place. State what substances this last weight includes, and how it differs in this respect from the first weighing.

Now open the bottle, and let the contents escape outward and the air diffuse inward, and observe the gradual change in weight.

4. The exp. illustrates the law of Conservation of Matter: *The products of a reaction weigh the same as the factors.* This shows that chemical exps. do not create or destroy matter, but merely change it.

97. LAW OF DEFINITE WEIGHT. QUANTITATIVE.

Supplies: balance, beaker, e.d., Na_2CO_3, HCl.

1. Weigh out very accurately 4^g of sodium carbonate, $Na_2CO_3.10H_2O$ — crystals that have not effloresced, — put it into a small beaker that has previously been weighed, and add, little by little, dilute HCl, covering the beaker loosely to prevent loss by effervescence. Describe the action, and write the equation. When the salt has all dissolved, evaporate all the water, and then weigh the dry salt that is left together with the beaker. Subtract the weight of the beaker, and the remainder is evidently the weight of sodium chlorid obtainable from 4^g of sodium carbonate. Taste the salt.

2. Compute the theoretical amount of NaCl which should result from 4^g of $Na_2CO_3.10H_2O$ — using the equation for this purpose — and compare it with your result.

3. Make a proportion to show the ratio of the weight of your product, sodium chlorid, to the weight of the factor sodium carbonate, as follows:

Sod. carb. taken is to sod. chl. obtained, as 1 is to x. This gives the weight of NaCl obtained to a unit of the carbonate taken.

4. Weigh 6^g of the sodium carbonate crystals, dissolve in dilute HCl as before; when all is dissolved add more HCl (to see whether there is any effect, or any difference in the final ratio), evaporate, weigh the resulting salt, make a proportion (as in 3), and compare the values of x. They should be the same. Taste the salt.

5. See whether the above exps. in any way illustrate the Law of Definite Weight, which is: *Any given compound always contains the same elements, and in the same ratio by weight.*

98. LAW OF DEFINITE VOLUME. QUANTITATIVE.

Supplies: Bunsen cells, electrolytic apparatus, H_2SO_4.

1. Connect *in series* two (or more) Bunsen cells of a battery, and attach the terminal wires to an electrolytic apparatus (Fig. 50) filled with water slightly acidulated with H_2SO_4. Notice the gas rising in minute bubbles, and that twice as much collects in one arm as in the other. Water is decomposing into its elements. By observing the graduated marks on the arms, it will be seen that no matter how much water is decomposed there will always be twice as much of one gas by volume as of the other.

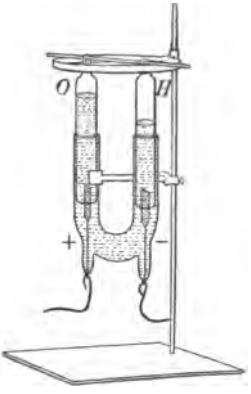


Fig. 50.

2. When the action has gone on far enough the gases should be tested with lighted splinters. The gas of smallest volume is found to be oxygen, the other hydrogen.

3. Does this exp. illustrate the following Law of Definite Volume? *Any given compound which is made up of gaseous elements always has the same elements in the same ratio by volume.*

4. Explain from this exp., by the use of Avogadro's Law, why the symbol of water is H_2O.

99. QUANTITATIVE EXPERIMENT—OXYGEN.

[Two persons should work together in Exps. 99 and 100.]

Supplies: balance, apparatus for making oxygen, $KClO_3$, MnO_2.

1. At the time of this exp. note the temperature with a centigrade thermometer, and the atmospheric pressure with a barometer graduated to millimeters.

2. Weigh accurately, using a delicate balance, 5^g $KClO_3$, and mix with the crystals 2 or 3^g of pure powdered MnO_2. Put the mixture into a t.t. with a tight-fitting stopper and delivery tube, and invert over the water-pan a flask of at least one and a half liters' capacity, filled with water. Apply heat, and, without rejecting any of the gas, collect it as long as any will separate. Then press the flask down into the water till the level in the flask is the same as that outside, if possible, and slide a glass plate under; then remove the flask, leaving in the bottom all the water that is not displaced. Weigh the flask with the water it contains; then completely fill it with water and weigh again. Subtract the first weight from the second, and the result will evidently be the weight of water that occupies the same volume as the O collected. This weight, if expressed in grams, represents approximately the number of cubic centimeters of water,—since 1^{cc} of water weighs 1^g,—or the number of cubic centimeters of O.

3. Reduce the temperature to the absolute scale by adding 273°. Now find what the volume of O would be at 273° absolute (or 0° C.) (Law of Charles or Gay Lussac), and 760^{mm} pressure (Law of Boyle or Mariotte). (If, *e.g.*, the temperature and pressure found were 27° C. and 758^{mm} and the volume of gas 1450^{cc}, the proportion for 0° C. and 760^{mm} would be

$$\left.\begin{matrix}300:273\\760:758\end{matrix}\right\}::1450:x=1311^{cc}=1.311^l.$$

Find the weight of this gas in grams (1^l H = $.0896^g$. V.d. of O = 16), which is the actual quantity of O obtained from 5^g $KClO_3$.

4. Compute the theoretical quantity from $KClO_3 = KCl + 3O$. Also compute your per cent of error; if it is above 5 or 10% do the exp. again. State any liabilities to error. One gram of $KClO_3$ instead of 5^g may be taken if it is preferred, and a proportionately small flask used.

100. QUANTITATIVE EXPERIMENT—HYDROGEN.

Supplies: hydrogen generator, etc., balance, flasks, C.P. Zn, HCl.

1. Arrange a trough for preparing hydrogen with a large flask filled with water, inverted on the shelf, and fastened in position. Put into a gas gen. 5^g, accurately weighed, of C.P. zinc, cover it with water, and place in position. Pour through the thistle tube measured quantities, say 5^{cc}, of HCl, and at once collect the escaping gas. This liquid HCl will displace its own volume of air, which will collect in the flask, and must be deducted from the volume of H obtained from HCl and Zn. Add HCl (in small and measured quantities) as it is needed. It is not necessary to use up all the zinc, but when the flask has been filled up to the neck or a little higher and *the action stops*, remove the flask, *observing the same precautions as in Exp. 99*, weigh the flask and what water it contains, fill it with water and weigh again; make the same computations as in Exp. 99. The remaining Zn must be carefully weighed, together with any impurities it contained, after having poured off or filtered the contents of the gen. Deduct the weight of the residue from that of the original zinc.

2. Take the temperature and barometric pressure of the air in the room, and reduce the volume of H to N.T.P. (*i.e.*, 0° C. and 760^{mm}).

3. Compute the theoretical amount of H to be obtained from using the given weight of zinc from the equation $Zn + 2HCl = ZnCl_2 + 2H$. The amount of HCl need not enter into the account. Compute your per cent of error, and if the result is not reasonably satisfactory, repeat the exp. State all the liabilities to error which you can think of. One or two grams of zinc instead of 5^g may be used in the exp., if desired.

This book should be returned to the Library on or before the last date stamped below.

A fine of five cents a day is incurred by retaining it beyond the specified time.

Please return promptly.

The
Athenæum
Press
Ginn & Company